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Wildlife and Range Research Needs in Northern Mexico and Southwestern United States: Workshop Proceedings

April 20-24, 1981
Rio Rico, Arizona

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Wildlife and Range Research Needs in Northern Mexico and Southwestern United States: Workshop Proceedings

**April 20-24, 1981
Rio Rico, Arizona**

Technical Coordinators

**David R. Patton, José M. de la Puente-E., Peter F. Ffolliott,
Sonia Gallina, and E. T. Bartlett**

Sponsoring Organizations

Forest Service, U.S. Department of Agriculture

**Subsecretaría Forestal y de la Fauna,
Secretaría de Agricultura y Recursos Hidráulicos**

The University of Arizona

**Instituto de Ecología, Sede Museo de
Historia Natural de la Ciudad de México**

Man and the Biosphere Program

**Forest Service, U.S. Department of Agriculture
Washington, D.C.**

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Preface

This workshop developed as a result of the sponsoring agencies' desire to cooperate in the exchange of technical information on range and wildlife problems common to Mexico and the United States. The format of the workshop was to present background papers to summarize conditions in Southwestern United States and Northern Mexico, to present information on current research efforts in both countries, and then, in three technical working groups, discuss identifiable problems and recommend priorities and opportunities for cooperative cooperative research and exchange of information.

Many people assisted in making arrangements and providing support, but we especially want to express our appreciation to the Man and Biosphere Program, U.S. National Committee and The University of Arizona for their financial assistance; to the Coronado National Forest and Nature Conservancy for conducting field trips; and to Josephine Gomez and Phyllis West for their excellent handling of the administrative details.

Papers were provided camera-ready for printing by the authors, who are thus responsible for their content and accuracy. Opinions expressed may not necessarily reflect the position of the U.S. Department of Agriculture.

The importance and success of this workshop were summarized very well in the closing remarks made by Jay Blowers:

"When we attend scientific meetings, frequently we are so wrapped up within our own speciality that we tend to forget that the whole focus of this kind of meeting is human beings. The needs of humans and the satisfaction of those needs in a rational way is what it is ultimately all about. We can argue about the value of wildlife as a resource, or the value of range as a resource, but in the real world what we are talking about is the economic value of wildlife."

Economic value could include aesthetics, as well as practical value. The question is, how can we manage the resources of this world to improve the life of human beings for not only for those who exist today, but for future generations and they are going to be big generations. That is really the task that scientists have to face. We have to

look ahead, such as emphasized by an old Chinese proverb which says, "It is better to light one candle than to curse the darkness." This workshop was especially stimulating in that we have lit many candles and we have indeed illuminated a path to greater and more fruitful cooperation between our two countries and between us as scientists and individuals.

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Welcoming Remarks ✓

Jay H. Blowers, Executive Director
U.S. Man and the Biosphere Program

It is a distinct pleasure and an honor to have this opportunity to welcome you to this workshop on Wildlife and Range Research Needs in northern Mexico and the southwestern United States. It is particularly gratifying that such a large number of our colleagues from Mexico is able to participate.

Approximately one year ago, a group of high level natural resources policy makers from the United States, Mexico, and several Central American nations gathered together in Durango, Mexico, to participate in a seminar on the "Social and Environmental Consequences of Natural Resources Policies." Twenty invited and volunteer papers on a variety of topics relating to natural resources policies formed the basis for discussion among the participants. Through these discussions, a valuable dialogue was initiated.

Dialogue is essential if common problems are to be identified and cooperation encouraged, but, ultimately the dialogue must lead to actual research on real problems. That is the task presented to us by the organizers of this workshop. We are expected to take that next step--to move from dialogue to action by identifying specific cooperative research or information sharing projects which will lead to better management of the range and wildlife resources in northern Mexico and the southwestern United States. By sharing our knowledge and working together, we can be more effective than working separately.

The geographic regions which are the focus of this workshop have common physiographic and ecological characteristics. Indeed, ecosystems are not limited by political boundaries, they transcend them.

The regions we will look at also share similar types of problems: water is scarce; populations in the regions are growing; urban areas are spreading. Care and sound management of the fragile natural systems that must support life in the regions are essential if these systems are not to become overstressed. There is a possibility that we are already approaching a danger point on the U.S. side.

In order to conserve and manage the natural resources of these regions, we need more baseline data about the resources; the numbers and types of plants and animals that exist; their potential value; how they react to stress; what species may be endangered; these are the kinds of information needed. The list of needs is extensive.

The structure of this workshop has been artfully constructed by the organizers so that during the ensuing four days we will progress from the general to the specific. To establish a common foundation of understanding we will begin with descriptions of the "Geographic, ecological, and cultural aspects of northern Mexico and the southwestern U.S."

We will then proceed to a discussion of the "Cultural aspects of wildlife and range management in the two regions." This is singularly important because all too often, the human element is not integrated into scientific research on natural systems.

This afternoon, we will look at research underway in existing biosphere reserves as well as some new opportunities for research.

Tomorrow morning, we will share information about "current research strategies for range and wildlife management in Mexico and the U.S." The afternoon will be devoted to technology transfer and research needs. At this point, we will be formed into task groups to develop the recommendations for cooperative research and/or information sharing projects that are to be the product of this workshop. Reports of the task groups will be presented at the final session on Friday.

As you can see, we have several days of hard work ahead of us. I am sure that they will be satisfying and productive days.

And now, a word about the Man and the Biosphere Program. As you are aware, there is an urgent requirement to conserve and manage the natural systems which contain and support life on this planet. In fact, this may be the most urgent task facing humankind today. The natural systems of earth are being subjected to increasingly heavy pressure by mounting numbers of human beings whose needs must be met. If these systems are to continue to supply the water, food, fuel, shelter, medicines, and other benefits as they have in the past, then we as human beings must learn to be careful, conscientious stewards over them.

The Man and the Biosphere Program of the United Nations Education, Scientific and Cultural Organization (UNESCO) is dedicated to the objective of providing the scientific knowledge and trained personnel needed to manage natural resources in a rational and sustained manner. Currently, 96 nations are involved in cooperative projects

ranging from tropical forests through grasslands to the study of urban areas as ecological systems. Research under the MAB Program is designed to help provide the kind of information needed to solve practical problems of resource management. It also aims to fill the still significant gaps in our understanding of the structure and functioning of ecosystems and of the impact of different types of human intervention. MAB research also emphasizes an interdisciplinary approach to the complex problems of resource management.

In September, the Man and the Biosphere Program will mark its tenth year of effort with a scientific conference in Paris. During this conference, the Program will be vigorously evaluated and new directions charted so that MAB can improve its contribution to the resolution of natural resource management problems.

Thus, it is fitting that MAB is associated with the MAB Program of Mexico in helping to sponsor this workshop.

At the Durango seminar, Professor G. R. Stairs, Director of the Duke University Center for Resource and Environmental Policy Research quoted from Latin to establish a theme for that meeting. I believe the quotation can serve equally well as a theme for our workshop. The quotation is:

"Omnia mutantur nos et mutamur in illis"

"All things are changing and we are changing with them"

We are living in a time of accelerating change and we must learn to regulate and manage that change in a rational, productive way. That is the fundamental task of the MAB Program and of this workshop.

In closing, thanks are in order for the organizers and sponsors of this workshop. They are:

The Subsecretary of Forestry and Wildlife of Mexico

The Institute of Ecology of Mexico

The U.S. Forest Service

The U.S. National Park Service

The Nature Conservancy of the United States

The University of Arizona

Special thanks to those who have prepared papers and who will serve as moderators and group leaders. Last but certainly not the least, thanks to all of you who are participating in the workshop.

Now, without further ado--to work.

Moderator's Comments: ²⁴⁵Geographic, Ecologic, and Cultural Aspects of Northwest Mexico and Southwest United States¹

Eng. José M. de la Puente-E.²

It is a pleasure to participate in this workshop attended by people who bring experiences and results from such well known institutions as UNESCO's Man and the Biosphere, the Institute of Ecology of Mexico, the School of Renewable Natural Resources of the University of Arizona, the Universidad Autónoma de México, the U.S. Forest Service, other prestigious organizations, and the Forest and Wildlife Department of Mexico which I represent. I bring you a warm greeting from Mr. Avelina B. Villa Salas, Subsecretary of Forestry and Wildlife of Mexico, who was especially interested in being with you, but unfortunately the many obligations conferred upon him by his important position, kept him from traveling to this land of beautiful Arizona.

THE ZONE OF MUTUAL INTEREST

Although the northwest of Mexico and the southwest of the United States, the territory whose study brings us together, are separated by geographic and political divisions, they practically are one ecosystem, with more similarities than differences in temperature, rainfall, wildlife, vegetation, and other factors.

These regions not only have similar ecologic characteristics, but history joins them in many ways, beginning with their ethnic and cultural origin itself.

Why, then, present separately the characteristics of the southwest of the United States and those of the northwest of Mexico when we could handle them as one entity? The reason is the difference in the development of the two countries, whose evolution has affected differently the natural resources of each region, bringing about different experiences and results.

¹Paper presented at "A Workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States." Rio Rico, Arizona, April 20-24, 1981.

²Eng. Jose Maria de la Puente, E. is Director General of the Technical Support Unit, Subsecretary of Forestry and Wildlife in the Secretary of Agriculture and Hydrologic Resources, Mexico.

Our meeting together to discuss these experiences will no doubt be beneficial in the handling of natural resources on both sides of the border, especially the wildlife.

WILDLIFE AND ITS ENVIRONMENT

In this area we feel that one of the strong points of this meeting is the joint study of wild animals and the factors which affect their existence, that is the environment.

There are examples of wildlife that perhaps man should imitate as far as an ecologic environment without geographical limits. Such is the case of eagles and condors. Also other birds and even migratory insects, like the Monarch butterfly which migrates from Canada before winter, throughout the U.S., to hibernate and reproduce in the neovolcanic Sierra of Mexico, where we witness every year this magnificent spectacle.

And what about the gray whale? The crossing of these cetaceans from the Behring Sea to Baja California is another example and another unique spectacle for our countries.

THE SUBJECT OF SESSION I

The subject of the first workshop is the geographic, ecologic, and cultural characteristics of the zone of mutual interest; these will be fully described in the next two presentations by Mr. Melo and Mr. Smith. Also we have the presentation of separate studies with respect to wildlife and the natural vegetation that supports it, given by Mr. Reyes and Mr. Downing.

And afterward, the works of this first section will culminate with the presentation of a film concerning the concept and the meaning of this ecologic unit which we call habitat, with comments by one of the principal organizers of this binational event, Dr. David Patton.

CLOSING REMARKS

It does not take an expert to realize that the Chihuahuan Desert extends equally on both sides of the border, and that the conifer forests

of Chihuahua and Arizona not only have the same flowering structure, but their numbers and their development are very similar in the Western Sierra Madre as well as in some forests of the Rocky Mountains.

Similarly, the Sonoran Desert does not seem to be aware of a boundary line; its characteristic manifestations are found in the land of the Yaquis as well as in the land of the Navajos. Proof of this are the pure sand deserts in the city of Caborca, Sonora, and in Yuma County in Arizona.

Our conifers in northern Baja California are unique; except for the pinyon pine, they do not exist anywhere else in our country. However, the majority of these species do exist in the Sierra Nevada of upper California.

If the examples of vegetation are so similar on both sides of our common border, we must admit that wildlife--considered a product of the environment--must necessarily be similar. And just by way of example we have the white-tailed deer,

pronghorn antelope, black bear, grizzly bear, peregrine falcon, condor, quail, and the bighorn sheep. Perhaps we have mentioned these species particularly because, in some cases, they are in danger of extinction.

We must realize then, that in our western region we not only have similar vegetation and wildlife, but we face also similar problems derived from their nature and their management.

This unique occasion where technicians of two neighboring countries are meeting is like a basis--an ideal habitat--to develop together studies, policies, and actions which will allow us to delve into the knowledge and the management of natural resources which are so vital for the well-being of man in this desertic region of the American continent.

And finally, if we can know the vegetation and the wildlife better, I believe that we will know ourselves and there will be better understanding between us.

Geographic and Ecologic Description of the Northwest of Mexico¹

Jesus Velázquez-Pérez² and Carlos Melo-Gallegos³

Abstract.--This paper describes the northwest of Mexico, its physiography, climate, soil, and biotic associations, including the Ethnic Groups for their importance in the development of traditional technology.

INTRODUCTION

The northwest of Mexico is a vast region, characterized by its aridity; it contains a great variety of biotic associations, both vegetable and animal. This zone is of utmost importance because of its nutritional contribution to the country, thus the need to study the arid and semiarid ecosystems which constitute it.

LOCATION

Conventionally, and to suit the purpose of this meeting, the northwest of Mexico is considered to include North and South Baja California, Sonora, and part of Durango. This region has a surface area of about 383,720 km², and contains important ecosystems of the arid and semiarid zones of Mexico.

OROGRAPHY

The existing orography is the result of volcanic activity which occurred at the end of the Cretaceous Mesozoic and during the Tertiary Cenozoic, when the Western Sierra Madre and the California Ridges originated.

The Western Sierra Madre runs parallel to 300 km of the Sonoran coast. It begins about 50 km from the U.S. border, and in this region it reaches its maximum width and height, about 2000 meters above sea level; then it turns south into chihuahuan territory. Faults, which still exist, and isolated hilly ranges, were formed at the beginning and presently form vast zones of ranges.

The volcanic activity along the cracks covered the old relief with extrusive materials.

From north to south the Western Sierra Madre has local names such as: Los Ajos, Buenos Aires, La Purica, Nacosari, Aconchi, San Antonio, Tabaquito, Pulpito, Horcasitas, and others.

The Serrania Transcaliforniana (Transcalifornian Ridge) runs along 1430 km from the San Joaquin Valley in the High Peninsula. Its range originated in the Cretaceous period, when the depression creating the Gulf of California occurred. Once the body of the ridge was formed, the southern part of the peninsula underwent intense volcanic activity creating promontories such as Tres Virgenes and La Giganta. The mountainous system is continuous, and acts as a dividing barrier whose eastern slope is narrow, steep, and ends close to the sea. The western slope, on the other hand, is at first abrupt, and then becomes a wide and smooth coastal plain.

The Serrania Transcaliforniana has local names as it runs from north to south. In the north end Sierra de Juarez is crowned by wide and high plateaus; San Pedro Martir has peaks over 2300 meters above sea level and it has some fragmented hills toward the southern part; in the central northern part we find Santa Catalina and Calamajue Ranges, and the San Borja, Mulege, La Concepcion, La Giganta, San Antonio and others in the south.

The second important morphologic unit is formed by the extensive Sonoran coastal plain, which is on the average about 100 meters above sea level with a width in the northern part of about 250 km, narrowing as it runs south. This flat surface was submerged as the sierra rose, and it emerged later to be exposed to the sporadic volcanic activity of the Tertiary, when El pinacate and Altar originated.

Another coastal plain is located in the Baja California peninsula; it is a strip about 1250 km long with variable width, which extends between the ridge and the Pacific Ocean. This smooth-sloped plain is covered basically by Mesozoic sediments in the plateaus, where salty lagoons are created by rain and deficient drainage.

¹Paper presented at "A Workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States." Rio Rico, Arizona, April 20-24, 1981.

²Jesus Velázquez-Pérez is Head of the International Relations Department, Technical Service Unit, Subsecretary of Forestry and Wildlife, Subsecretary of Agricultural and Hydrologic Resources, Mexico.

³Carlos Melo-Gallegos is Research Scientist at the Institute of Geography, National University of Mexico.

The third morphologic unit is the californian eastern slope, a narrow belt about 1200 km long with an average width of about 5 km. The slope has two parts: the deltaic alluvial flat formed by the Colorado River extending to Sierra de Juárez, and a second part formed by sedimentary rock plateaus and sporadic volcanic lavas.

The regions described above, because of their geographical location north of the Tropic of Cancer, are in the belt of the great desert zones of the world. High temperatures, and the scarcity and irregularity of rainfall, cause extreme aridity.

CLIMATE

Based on Koppen's climatic classification, modified by Garcia, the following climatic groups are located in the region: desert, semidry, semiarid, steppe dry, subhumid, temperate and mediterranean-type temperate.

The desert (BW) climate is characterized by average yearly temperatures that fluctuate between 180°C and 220°C, and below 18°C in the coldest month. This climate covers about 50% of the region, and because of the influence of geographic factors it is manifested as extremely warm (BWh¹) in the middle and southern parts of the Sonoran plain and along the western slope of the californian ridge. During the cool winter it changes to semiwarm (BWh) in the desert zone of Altar and the coastal plain up to Guaymas. In the peninsula it extends to medium ranges and flat zones next to the coast, and it also extends to the Vizcaino desert. The dry climate becomes temperate (BWk) near the eastern slope of the Sierra de Juárez and the San Pedro Mártir Sierra.

The semidry or semiarid (BS₁) climate is characterized by average yearly temperatures that vary between 12° and 22°C. In the slopes of the Sierra Madre the climate reaches its most extreme conditions (BS₁h¹) with average yearly temperatures above 22°C. Influenced by a cool winter, the climate of some depressions of the Sierra Madre becomes semiwarm (BS₁h), and in relatively elevated areas the temperature drops to 3°C during winter, which causes temperature (BS₁k) conditions.

The steppeland has average yearly temperatures above 22°C, although along the side slope of the Sierra Madre the coldest month exceeds 18°C. The Sonoran plains have a very warm (BS₀h¹) climate which is more favorable (BS₀h) in the middle slope of the Sierra Madre and in La Giganta. The middle slopes of Sierra de Juárez and San Pedro Mártir have a temperate (BS₀k) climate.

The temperate subhumid climate ranges from semiwarm (ACW⁰) to dry temperate (C(CW⁰), and humid temperate (ACW₂); its average yearly temperatures vary between 12-18°C. This climate exists only in the elevated areas of the Sierra Madre.

The mediterranean (C_s) climate is characterized by winter rains that contribute more than 36% of the total annual rainfall; the temperature varies

from 12-18°C, the coldest month being between -3 and 18°C, and the warmest month below 22°C. This climate exists in the summits of the Sierra de Juárez and San Pedro Mártir.

PRECIPITATION

Within this great region there is a spacious strip that covers most of the western plain of the peninsula and extends towards the Mexicali Valley and the Delta of the Colorado River, to penetrate the Altar desert and the Northern Coast of Sonora. This strip has an annual precipitation of less than 100 mm.

In the elevated areas of the peninsula and along the Sonoran plain, rainfall is between 100-200 mm.

A zone with precipitation of 200-400 mm is found in the middle slopes and high areas of the californian ridge and in the lower slope of the western Sierra Madre.

Precipitation reaches 400-900 mm in the spurs of the Sierra Madre, even in the more elevated areas. At a local level, the maximum yearly precipitation records in Sonora stations are: Yecora 999 mm, Tezocoma 695 mm, San Bernardo 646 mm, and San Pedro Mártir 682 mm. The minimum volumes of rainfall have been recorded in Mexicali with 32 mm, Altar Desert with 35 mm and in the Vizcaino Desert with 49 mm.

HYDROGRAPHY

Due to the orographic characteristics of the western Sierra Madre, there are large river basins in the Sonora Desert which run down from north to south and generally turn west to cross the coastal plain and flow into the Gulf of California. From north to south the main river basins are the Colorado, Magdalena, San Ignacio, Sonora, Yaqui, and Mayo. The Colorado River marks the boundaries of the states of Sonora and North Baja California; its longest section is in the U.S.

The Magdalena River is 385 km long with a basin of about 2500 km² and an average yearly flow of 48 million m³; its waters form the Cuauhtemoc reservoir.

The San Ignacio river basin covers about 2840 km² and its average yearly flow is 27 million m³.

The Sonora River originates near Cananea. It is about 420 km long, and its basin is about 2600 km²; the Abelardo L. Rodríguez dam stands in the city of Hermosillo.

The Yaqui River is the most important flowage, with a basin of 80,000 km² and an average yearly flow of 190 million m³. Three dams have been built on it: La Angostura, Plutarco E. Calles, and Alonso Obregon; these are utilized for the generation of electricity and for irrigation.

The Mayo River has a basin of 16,000 km² and its average yearly flow is 82 million m³. The Adolfo Ruiz Cortines dam stands there.

In the Baja California peninsula the scarce and irregular precipitation together with high temperatures cause the evaporation of great amounts of water which results in critically low hydrologic systems. In the coastal areas where the sierra approaches the shore, the rivers are short and scant, and they frequently lose their volume in the sandy shores. The only flowages which escape those conditions and could qualify as rivers are Las Palmas, Guadalupe, San Antonio, San Telmo, and El Rosario, which descent from the western slope of the Sierra de Juárez and San Pedro Mártir.

SOILS

The influence of climatic factors and their interrelationship to relief and rock formation create incipient soils of low fertility.

According to the FAO/UNESCO classification, more than 80% of the great region is covered by soils known as Yermosols and Kastanozems; the remaining 20% includes Xerosols, Lithosols, Regosols, Luvisols, and Fluvisols.

The Yermosols are characterized by a superficial layer low in humus and by a subsoil rich in clay with deposits of gypsum or caliche; sometimes they are saline and contain rocky formations; these extend along wavy areas of the peninsula and in the sonoran coastal plain.

The Kastanozem soils have a dark upper layer, rich in organic matter and with good drainage. They are located on moderate slopes in humid temperate climates such as in the western Sierra Madre and San Pedro Martir.

The Xerosols are characteristic of the more arid regions, poor in humus, have clayey subsoil, and do not retain moisture. These soils are located in the spurs of the Sierra Madre.

Lithosols are stony soils with little depth and acceptable organic matter; they are developed along abrupt slopes in temperate-humid climates characteristic of the higher elevations.

The Regosols are calcareous and are found in the lower middle slopes of the Sierras de Juarez and San Pedro Martir.

The chromic Luvisols are washed soils of moderate fertility and are highly susceptible to erosion. They are located on steep slopes in the Valleys of Tijuana and San Jose del Cabo.

The Fluvisols are formed by dispersed river drifts and are located north of the Peninsula of Baja California in the zone of the Laguna Salada, near the Colorado River.

VEGETATION

Due to the adaphic characteristics of the great region, there is a variety of vegetable communities:

1. Leafy Pine-Spruce. This type of community is located in the higher elevations of the western Sierra Madre and, in the peninsula, in Sierra de Juarez and San Pedro Martir.

The main species of this community are: Pinus arizonica, P. engelmanni, P. durangensis, and P. chihuahuana; Pseudotsuga sp., Picea sp., Abies sp., Alnus sp., Populus sp., Quercus sp.

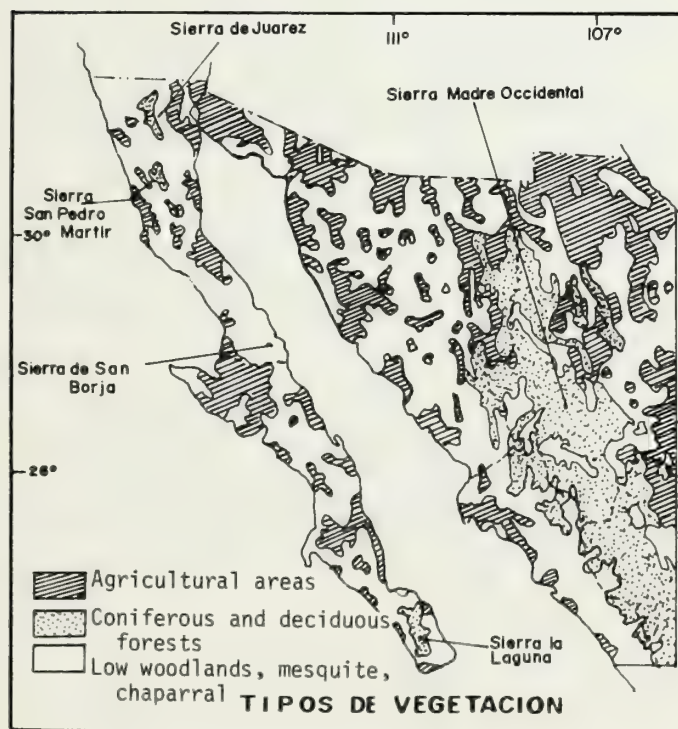
In the Sierras de Juarez and San Pedro Martir, the main species are (Fig. 2): Pinus jeffreyi, P. contorta, P. lambertiana, P. coulteri, Abies sp., Libocedrus sp., Populus sp., Quercus sp., Pinus radiata, P. remorata, and P. muricata on the island of Guadalupe.

2. Pine-Oak-Manzanita. This community is located primarily in the spurs of the western Sierra Madre and in some of the California Ridge spurs. This group grows about 1800 to 1600 meters above sea level and the main species are:

Pinus cembroides, Quercus spp., Arctostaphylos spp., and many grassy species.

In the southern part of the peninsula in the Sierra de la Laguna, and at 1600 meters above sea level, there is a forest whose main species are Pinus cembroides, Quercus spp., and in sheltered parts Populus monticola also grows.

3. In the Sierra de Juarez the chaparral is formed basically by Juniperus sp., Quercus sp., Arctostaphylos dupranea, and Artemisia ludoviciana albula. In the Sierra San Pedro Martir the chaparral is made up of Arctostaphylos dupranea, Artemisia ludoviciana albula, and Eriogonum spp.



In the southern region of the peninsula at altitudes no greater than 200 meters above sea level, there is a very xerophytic thicket whose main species are Pachycereus pringlei, Machaerocereus gummosus, Lemaireocereus thurberi, Fouquieria splendens (ocotillo) and Simondsia sp. (jojoba). The latter, with specific geographic variations, exists in a large part of the Gulf.



Fig. 2.-- Forest of predominantly Pinus contorta in the Sierra de Juarez, B.C.N.

4. Pasture. This community extends from the foot of the mountainous areas at 1400 meters above sea level to the ocean shore.

In the region of the Sonora River basin the main species are: Bouteloua spp., Hilaria sp., Aristida sp., Muhlenbergia sp., Eragrostis sp., and Bromus sp.

In the Sierras Juarez and San Pedro Martir there is a pasture formed mainly by Bromus sp., Muhlenbergia sp., Festuca sp., and Agrostis sp.

In the great pasture region of the Sonoran plain there are three types of thicket:

- a) Microphyllous thicket: made up by the main species: Cercidium sp. (palo verde), Prosopis sp. (mesquite), Olneyatezota, Fouquieria splendens (ocotillo), Larrea tridentata, Acacia sp. Fig. 3.
- b) Rosette type thicket: this includes Agave spp., Dasyliirion wheeleri, Yucca spp., and Nolina spp.
- c) Crassicaule thicket: species representative of this community are: Carnegia gigantea (saguaro), Cephalocereus sp., Echinocactus sp., and Lophocereus sp.



Fig. 3.-- Desert shrubland of predominantly ocotillo (Fouquieria splendens), pithaya (Lemaireocereus spp.), gobernadora (Larrea tridentata), and vinorama (Acacia sp.).

In the peninsular region between 250 and 800 meters above sea level there is a xerophytic thicket formed by specimens between 6-10 meters tall. The most important species in this thicket are: Bursera microphylla, Lysiloma diva ricata, Berberis sp., Acacia sp. (vinorama), Cyrtocarpa edulis, Pachycereus pringlei, Ficus palmeri and Jatropha cenera.

WILDLIFE

The great variety in types of vegetation of the northwest offers also a rich variety of habitats suitable for wildlife of a great diversity.

Due to the nature of this information and because other conferences will be more specific, this paper will mention the species reported by greater regions; their presence at a local level could be affected by habitat disturbance.

The following species have been reported in the mountainous regions of the western Sierra Madre and the California Sierras: Mountain lion (Felis concolor), wolf (Canis lupus), black bear (Ursus americanus), gray fox (Urocyon cinereo argenteus), javelina (Tayassu tajacu), racoon (Procyon lotor), otter (Lutra canadensis), rabbit (Sylvilagus sp.), golden eagle (Aquila chrysaetos), turkey (Meleagris gallopavo), band-tailed pigeon (Columba fasciata), peregrine falcon (Falco peregrinus) and others. The brown bear (Ursus arctus) has been reported in the western Sierra Madre. The California condor (Gymnogyps californianus) has been reported in the California ridge.

In the arid plain, depending upon the habitat of each species and the disturbance of the ecosystem, and up to altitudes of 1400 meters above

sea level, the following species have been reported: mule deer (Odocoileus hemionus), white-tailed deer (Odocoileus virginianus), coyote (Canis latrans), badger (Taxidea taxus), hare (Lepus californicus), striped skunk (Mephitis mephitis), bobcat (Lynx rufus), antelope (Antilocapra americana), kit fox (Vulpes macrotis), California quail (Lophortyx californica), osprey (Pandion haliaetus), road-runner (Geococcyx californianus), white-winged dove (Zenaida asiatica), mourning dove (Zenaidura macroura), chacuaco (Lophortyx douglasii) and others.

In this region and due to its importance as a big game animal, bighorn sheep (Ovis canadensis) is outstanding. This species has been observed from the coastal plain in the Altar Desert to the pine-grove zone of San Pedro Martir; its natural habitats are the valleys between mountains, and its main shelters are the uneven areas of difficult or no access. In Sonora they have been found from the area near the Kino Bay to the north area in El Pinacate zone, and east to the vicinity of Carbo. They have been observed at Johnson Peak, Sierra de la Peineta, Sierra de la Tortilla, Tepopa, and Arroyo Grande; in the northern zone: Sierra del Humo, Sierra del Carrizal, Palito Blanco, Palo Verde, Volcán del Elegante Tanque de Pápagos and El Pinacate. In the vicinity of Carbo they have been recorded in the Serranías de la India, Cobrisa, and Anacoretas.

In the peninsula they have been observed mainly, from the north, in the Serranía de Matomí, Mesa de las Palomas, and Cerro Canelo; to the south, in the Volcán de las Vírgenes, Serranía de Canipolé, Sierra de Cadejé, La Giganta, and Serranía de Tripui, near the San Luis Mission.

The estimated population for 1978 was 7500⁴, and 5500 of these were in the californian area.

In the coastal zone there is an important habitat for migratory birdlife. In the northern part of the peninsula there is a region where about 90% of the canadian geese (Branta canadensis), immigrating into Mexico, take shelter.

Within the great coastal region bird species such as royal tern (Thalasseus maximus), blue-footed booby (Sula nebouxi), snow goose (Chen hyperborea), white pelican (Pelecanus erythrorhynchos), redhead duck (Aythya americana), pintail duck (Anas acuta), Heermann's gull (Larus heermanni) and others.

ETHNIC GROUPS

Man, as an agent of change, plays an important part in the disturbance of the ecosystem, and his activity is determinative in order to restore the countryside and implement the desired equilibrium.

In the northwest of Mexico there are a series of ethnic groups with their own socio-cultural patrimony, and their existence has been invaluable in maintaining the biotic characteristics of the desert in balance.

Within the ethnic groups one can find from collectors to artisans, farmers and hunters, doctors and historians. The traditional practice of their customs, beliefs, or laws has allowed them to develop a series of naturalist technologies based on which they have existed throughout time in harmonious balance with the ecologic characteristics of the desert.

For these reasons it is important to study in depth the whole gamut of traditional technologies and information which the ethnic groups already possess, for the purpose of making a better judgement when interpreting the arid and semi-arid ecosystems of the area described. Once the laws, organizations and processes are known, it is possible to obtain data and technologies or needs which can affect the implementation of research projects.

Currently the Mayo and Tarahumara groups are located in the northwest of Mexico and in the confluence of the States of Sonora, Sinaloa, and Chihuahua. The Pima and Guarijio groups are located in the central border between Sonora and Chihuahua. Near Cd. Obregon (Cajeme) is the Yaqui group. The Seri group is in Punta Chueca across from Tiburon Island. The Papago group is in the northern part of Sonora; in the border between Sonora and California is the Cucapa group, and in the northern part of the peninsula are Kumiai, Cochimi, Paipai, and Kiliwa groups. In the central and southern part of the peninsula there have been reported relics of the Guaicura and Pericue groups, respectively (figure 4).

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Rangelands of Southwestern United States¹

E. Lamar Smith²

INTRODUCTION

Rangeland vegetation, soils and wildlife found in the southwest United States are diverse due to contrasts in precipitation patterns, temperature, elevation, topography, and geologic material. The objectives of this paper are to summarize in a very general way the geomorphic, climatic and edaphic environment, to describe the occurrence of major vegetation communities, and to make a few observations on ecological relationships and historical changes which are important determinants of management problems and research needs. The area considered is confined mainly to Arizona, New Mexico and West Texas, and emphasis is placed on non-forested rangelands.

PHYSICAL ENVIRONMENT

Geology-Geomorphology

Four major geologic provinces are represented in the area (Fenneman 1931). The Great Plains Province of eastern New Mexico and West Texas consists of flat high plains bounded by escarpments or canyons marking the limits of eroded basins along the Pecos and other rivers. This region is underlain by sedimentary rocks except in the northwest part where basalt flows form dissected mesas above the sedimentary formations. The Pecos River and headwaters of the Red, Canadian, and Brazos River drain this area.

Two branches of the Southern Rocky Mountains extend south into northern New Mexico on either side of the Rio Grande. The Sangre de Cristo Range east of the Rio Grande is composed of mainly granitic rocks and reaches elevations in excess of 4000 m. The San Juan and Jemez Mountains on the west side are somewhat lower and mainly composed of Tertiary volcanics.

Northwestern New Mexico and northern Arizona form part of the Colorado Plateau Province. This large area ranges from plains to highly dissected canyons and "badlands" composed of highly colored sandstones, shales, and limestones. The general elevation is in excess of 1500 m with some high

plateaus and peaks above 3000 m. Extensive areas of volcanic activity are found along and above the Mogollon Rim from west-central Arizona to west-central New Mexico. A well-known feature of this zone is the Grand Canyon through which the Colorado River flows.

From the Trans-Pecos region of Texas, across southern New Mexico, through southern and western Arizona extends the Basin and Range Province. This region consists of scattered, small fault-block mountain ranges, from 700 to 2500 m in elevation, separated by broad desert basins. The mountain ranges generally are composed of older sedimentary rocks or pre-Cambrian igneous rocks with some more recent rhyolite, andesite and basalt. The basins are filled to considerable depth with Tertiary and Pleistocene alluvium, occurring in bajadas, fans and pediments sloping away from the mountains to the valley floors. Many basins in New Mexico and West Texas have no external drainage and contain "playa lakes. In Arizona the valleys drain into the Salt, Gila and other rivers, most of which only flow seasonally.

Climate

The climate of the Southwest is also quite diverse. Since precipitation is probably the most important factor influencing the nature and use of these rangelands it is important to understand climatic patterns of the area. Annual precipitation is roughly correlated with elevation and ranges from about 75 mm in the southwestern Arizona desert near sea level to 750 mm in the highest elevations of Arizona and New Mexico (table 1). Average temperature decreases with elevation so that the effectiveness of precipitation generally increases with elevation. Elevations above 1800 m receive winter moisture mainly as snow. Seasonal temperatures vary greatly. The deserts of the southern part are hot in summer and mild in winter. Maximum temperatures may exceed 45°C in some areas. Only the extreme southwestern part of Arizona is essentially frost-free, and even there occasional frosts may damage winter crops. Temperatures in the mountains are cool in summer and cold in winter. Extreme low temperatures of -38°C have been recorded.

In addition to annual precipitation the seasonal distribution is an important factor influencing range and wildlife management. Winter precipitation comes from low pressure systems originating in the Pacific Ocean. These typically move northeasterly from Baja California across Arizona producing widespread gentle rains especially in central Arizona along the Mogollon Rim. Storm systems which ori-

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Table 1.--Principle vegetation types of southwestern United States (modified from Klemmedson and Smith 1978).

Vegetation Type	Elevation	Mean Annual	Characteristic Plants
	Range m	Precipitation mm	
Alpine	3650	750-900	Grasses, sedges, dwarf shrubs, cushion plants
Subalpine Conifer Forest	2800-3600	750-900	<i>Picea engelmannii</i> , <i>Abies lasiocarpa</i>
Mixed Conifer Forest	2800-3300	650-750	<i>Pseudotsuga menziesii</i> , <i>Abies concolor</i> , <i>A. lasiocarpa</i> , <i>Picea engelmannii</i> , <i>Pinus ponderosa</i> , <i>P. strobiformis</i> , <i>Populus tremuloides</i>
Ponderosa Pine Forest	2000-2800	480-650	<i>Pinus ponderosa</i> , <i>Festuca arizonica</i> , <i>Muhlenbergia montana</i>
Pinyon-Juniper Woodland	1300-2300	300-500	<i>Juniperus monosperma</i> , <i>J. osteosperma</i> , <i>Pinus edulis</i> , <i>P. cembroides</i> , short and mid-grasses
Oak Woodland	1200-2000	300-500	<i>Quercus emoryi</i> , <i>Quercus</i> spp., <i>Juniperus</i> spp., mixed tall-and mid-grasses
Interior Chaparral	1000-1800	330-650	<i>Quercus turbinella</i> , <i>Rhus</i> spp., <i>Arctostaphylos</i> spp., <i>Cercocarpus</i> spp., <i>Ceanothus</i> spp.
Plains and Great Basin Grassland	1100-2000	230-500	<i>Bouteloua gracilis</i> , <i>Hilaria jamesii</i> , <i>Agropyron smithii</i> , <i>Stipa</i> spp., <i>Artemisia</i> spp., <i>Atriplex</i> spp.
Desert Grassland	1000-1500	230-460	<i>Bouteloua</i> spp., <i>Aristida</i> spp., <i>Hilaria</i> spp., <i>Sporobolus</i> spp., <i>Prosopis</i> spp., <i>Acacia</i> spp., <i>Opuntia</i> spp.
Great Basin Desertscrub (cool desert)	700-1900	180-430	<i>Artemisia</i> spp., <i>Atriplex</i> spp., <i>Coleogyne</i>
Southern Desert Shrub (warm desert)	0-1000	75-250	<i>Larrea tridentata</i> , <i>Flourensia</i> , <i>Acacia</i> spp., <i>Cercidium</i> spp., <i>Ambrosia</i> spp., succulents, annuals

ginate farther north move across Nevada and Utah bringing snow to the mountains of northern Arizona and New Mexico. The result is that winter precipitation generally decreases from about 65-70% of the total in western Arizona to only 20-30% in West Texas.

Summer rainfall comes from moisture originating in the Gulf of Mexico. Rainfall during spring and summer is generally in the form of convective thunderstorms of high intensity, short duration, and localized occurrence. In the Great Plains area of Texas and New Mexico about 60-75% of the annual rainfall is in April-July. In southern Arizona April, May and June are very dry months, and the summer rain comes almost entirely from July to September. The three hot desert provinces in the Southwest are related to rainfall distribution; the Mojave Desert of California and western Arizona having winter rainfall, the Chihuahuan Desert of New Mexico and Texas mainly summer rainfall, and the Sonoran Desert of Arizona a bimodal distribution about equally split between summer and winter.

Another important characteristic of precipitation in the Southwest is variability, both in space and time. Annual rainfall in the Southwest is more variable than anywhere else in the United States, although prolonged sequences of dry years are less common than in the Great Plains. Timing and size of individual storms have important effects on vegetation. Winter rains are more general in occurrence but less reliable than summer rains. Summer rains are extremely variable over short

distances so that one end of a ranch may have normal rainfall and the other experience a drought in any given year. The concept of normal rainfall is not very meaningful; drought is the rule rather than the exception.

Soils

As might be expected soils reflect the diversity of climate, vegetation and parent materials in the region. Most of the soil orders in the U.S. Soil Taxonomy are represented. Moisture regions range from aridic to udic and temperature regions from hyperthermic to cryic or pergelic.

Soils formed over bedrock generally reflect the nature of the parent material. Soils formed on limestone are usually dark in color and lack strong horizon development. Granite, schist, gneiss and the lighter volcanic rocks, such as rhyolite, produce soils which range from very shallow coarse-textured surface soil over consolidated bedrock to deep, moderately-heavy textured soils with pronounced textural B horizons, depending on soil age and stability. Some, especially those derived from granite, may be underlain by decomposed or highly fractured bedrock which offers a medium for plant rooting which may extend several meters below the soil profile. Soils developed on basalt or alluvial/colluvial material rich in basalt are usually high in montmorillonitic clays and often are classified as vertisols (chromusterts). Sandstone generally produces soils of light to moderate texture, while shales produce heavy-textured, often saline, soils.

On the extensive areas of Pleistocene or more recent mixed alluvium of alluvial fans, pediments, stream terraces, and valley floors the soils reflect the complex depositional and erosional history of these land forms. Soil development is usually highly correlated with age and stability of the geomorphic surface. In general the red color, clay content, thickness of the B horizon, and development of calcic or petrocalcic horizons increase with soil age. Many of these older soils have had continuous development of up to a million years and thus reflect the influence of previous climates and vegetation communities. Some light-textured, immature soils are underlain by the buried B horizons of older soils which have important effects on deeper rooted plants. Many soils are high in calcium carbonate, reflecting highly calcareous sediments and/or exposure of pedogenic calcium carbonate by erosion of older soils. Gypsiferous soils occur mainly around old lake bed deposits in New Mexico and West Texas. Saline and alkali soils occur mainly in association with marine sedimentary rocks of the Colorado Plateau or closed desert basins in Southern Arizona, Southern New Mexico and West Texas.

VEGETATION TYPES

Among the many well-known studies of vegetation distribution and zonation in the Southwest are those of Merriam (1890), Shreve (1915), Livingston and Shreve (1921), Shantz and Zon (1924), Whittaker and Niering (1965), Clements (1920), Whitfield and Beutner (1938), Pearson (1931), Nichol (1937), Bailey (1913), and many others. Recent vegetation maps have been published by Brown and Lowe (1977) and Donart et al (1978). Classification of communities is not consistent among these authors.

The Desert Types

Southern Desert Shrub

At lower elevations in the foothills and valley from West Texas across southern New Mexico and Arizona into California are the warm-desert shrub types. The most characteristic dominant throughout the zone is Larrea divaricata. Associated species are strongly influenced by the precipitation described above for the Mojave, Sonoran and Chihuahuan deserts. The Sonoran desert is richer in life forms than the others due to its bimodal precipitation pattern. Characteristic species are Cercidium microphyllum and C. floridum, Olneya tesota, Ambrosia dumosa and A. deltoidea, Carnegiea gigantea, Hilaria rigida and many cool season annuals. These annuals make a colorful display of wildflowers and furnish substantial forage for livestock after favorable winters (fig. 1). Characteristic plants in the Chihuahuan Desert are Flourensia cernua, Acacia vernicosa, and Koeberlinia spinosa. Hilaria mutica or Sporobolus airoides are common on floodplains. Cool season annuals are less abundant reflecting the colder, drier winters. Atriplex spp. are common in all three areas.



Figure 1.--Spring aspect of Sonoran Desert vegetation near Picacho, Arizona.

Great Basin Desert Scrub

In the drier and lower-lying areas of northern Arizona and northern New Mexico occur representations of the cold-desert types found more extensively in Nevada, Utah and Colorado. The most characteristic species are Atriplex canescens, A. confertifolia, Sarcobatus vermiculatus, Coleogyne ramossissima, Artemisia spp., Tetradymia canescens, Ceratoides lanata. Soil pH, salinity and texture have a marked influence on plant composition in this area. Common grasses on saline soils are Sporobolus airoides and Distichlis stricta.

Grassland, Woodland and Chaparral Types

At elevation and precipitation levels intermediate between the desert types and the forest zones are a number of vegetation types ranging from pure grassland to dense chaparral or open woodland. The occurrence of the types and the species in them is strongly affected by soils and climatic patterns and thus the elevational sequences or appearance may vary considerably from one area to another. Widespread changes in these vegetation types due to natural and man-caused influences have further complicated classification and interpretation of communities.

Desert Grassland

The Desert Grassland occurs above the desert shrub types from western Arizona to southern New Mexico and West Texas. It occurs most characteristically on the bajadas, higher valley floors and other alluvial parent materials in the Basin and Range Province. A distinction is usually made between the upper grassland at higher elevation and/or rainfall which has more affinities to the Shortgrass Plains and the lower grassland containing more desert species (Martin 1975). Bouteloua curtipendula, B. gracilis, B. hirsuta, Eragrostis

intermedia and curly Hilaria belangeri are among the most characteristic species in the upper grassland (fig. 2). This type is most extensive in southeastern Arizona and in West Texas, but relatively uncommon in New Mexico. The main dominants in the lower grassland are Bouteloua eriopoda and Muhlenbergia porteri. Bouteloua rothrockii and several species of Aristida are very common in the lower grassland. Taller grasses found in mesic situations throughout include Botriochloa barbinodes, Leptochloa dubia, Digitaria californica, Heteropogon contortus, and Setaria macrostachya. Sporobolus wrightii, S. airoides, Hilaria mutica, or bosques of Prosopis juliflora are common on floodplains.

Shrubs and cacti range from sparse to very dense in this zone. In fact, in many areas the desert grassland does not have a grassland aspect. Common are species of Prosopis, Acacia, Flourensia, Larrea, Fouquiera, Gutierrezia, Happlopappus, Yucca, Agave, Opuntia, Nolina, and Dasyllirion.

Plains Grassland

On the high plains and mesas of eastern New Mexico and adjacent Texas are the Plains Grasslands which are typical of the shortgrass or mixed prairie vegetation of the Great Plains (Heerwagen, 1956). Dominant species are Bouteloua gracilis, Buchloe dactyloides, Agropyron smithii, and Hilaria jamesii. Numerous other shortgrass species occur as well. Hilaria mutica is common on floodplains. Mesic sites caused by sandy or rocky soils may support tall grasses often in association with Artemisia filifolia, Yucca or Quercus havardii.

To the south and west, where the moisture becomes less effective due to warmer temperatures, the Plains Grassland merges into Desert Grassland. As summer rain becomes more erratic to the west of the Rio Grande in New Mexico, the Plains Grassland changes to Great Basin Grassland.



Figure 2.--Desert grassland - oak woodland transition near Sonoita, Arizona, Santa Rita Mountains in background.

Great Basin Grassland

These grasslands were often called shortgrass on some earlier maps where they occur in northwest New Mexico and northern Arizona (Nichol 1937, Clements 1920). However more recent maps have made a distinction based mainly on the lack of Buchoe dactyloides and greater importance of Hilaria jamesii, Oryzopsis hymenoides, Artemisia spp. or other elements typical of the Great Basin region. Bouteloua gracilis and Agropyron smithii are very important species in this type also. Due to the low and unreliable rainfall, this area is less productive and has been more widely deteriorated than the other grassland types.

Pinyon-Juniper Woodland

The Pinyon-Juniper Woodland is common over a very large area of northern Arizona, most of New Mexico and West Texas. The Pinyon-Juniper type merges with Ponderosa Pine Type at higher elevations and with Desert Grassland, Plains Grassland, Great Basin Grassland or even desert types on its lower fringes. Juniperus monosperma is the most widespread species, occurring throughout New Mexico, and parts of Arizona and Texas. Juniperus osteosperma is common in Arizona, sometimes mixed with J. monosperma. Juniperus pinchotii occurs in Texas. Juniperus deppeana is common at higher elevations, often merging into the pine type. Juniperus spp. are often associated with Pinus edulis or P. cembroides. Although this vegetation type is widespread and easily recognizable there are no species endemic to the type except the pinyon and juniper themselves (West, et al 1975). Understory shrubs and herbaceous plants are typical of those of adjacent grassland, forest or shrub types, and consequently, vary widely from place to place. Juniperus spp. have extensively encroached on associated grassland and sagebrush types.

Oak Woodland

Oak Woodland or encinal is found in southeastern Arizona, southern New Mexico and West Texas. It is characterized by open to moderately dense stands of Quercus spp; Quercus emoryi is the most widely distributed and typical. At its lower limits it forms open savannahs with a vigorous understory of grasses typical of the upper Desert Grassland (fig. 2). At its upper limits it tends to be more dense and may contain Juniperus deppeana, Pinus cembroides and a number of chaparral species with which it shares the same elevational range.

Chaparral

Chaparral occurs in central Arizona as a remnant of a once much more extensive flora which extended from California to Texas (Darrow 1961). It is often called Interior Chaparral to distinguish it from the California Chaparral which is similar in appearance but has different species and climate.

Dominant plants are mainly evergreen sclerophyllous shrubs. *Quercus turbinella* is the most characteristic species. Others commonly associated with it are *Arctostaphylos pungens*, *A. pringlei*, *Ceanothus greggii*, *Cercocarpus* spp., *Rhus ovata*, *R. trilobata*, *Rhammus crocea*, *Garrya wrightii* and *Cowania mexicana*. Understory species are characteristic of Desert or Plains Grassland.

Chaparral may range in elevation from the Desert Shrub to the Ponderosa Pine Types. It usually occupies the deeper, coarse-textured soils, especially those derived from granite, while juniper or grassland is more common on the heavy soils (Hibbert, et al 1974, Saunier 1964). A number of the Chaparral species are found in the pine or woodland types.

Forest Types

Ponderosa Pine

The lowest true forest type in Arizona and New Mexico is the Ponderosa Pine type. *Pinus ponderosa* occurs as an extensive pure type across the Mogollon Plateau of central Arizona into New Mexico. At lower elevations in the northern part of the region it merges with the Pinyon-Juniper and may contain significant amounts of *P. cembroides*, *Juniperus scopulorum*, *Robinia neomexicana* and *Quercus gambelii*; in the southern parts, *Juniperus deppeana* and *Quercus hypoleucoides* may fill this niche.

Other Forest and Associated Types

With increasing elevation and moisture the Ponderosa Pine Type grades into a Mixed Conifer Type. Along with *Pinus ponderosa*, occur *P. strobiformis*, *Pseudotsuga menziesii*, *Abies concolor*, *A. lasiocarpa* var *arizonica*, *Picea pungens*, *P. engelmannii* and *Populus tremuloides*. At still higher elevations, mainly in New Mexico, is the Subalpine Conifer Forest dominated mainly by *Picea engelmannii* and *Abies lasiocarpa*.

Associated with these conifer types are the Subalpine Mountain Grasslands dominated by *Festuca thurberi* in New Mexico and *F. arizonica* in Arizona. Above timberline is a limited amount of Alpine Vegetation occurring in the high peaks of the Sangre de Cristo Range in New Mexico and on the San Francisco Peaks in Arizona.

Riparian Vegetation

In the semi arid Southwest the presence of additional water takes on great significance for both plants and animals. Watercourses which have surface or subsurface flow through most of the year support distinctive riparian communities. At higher elevations such species as *Populus* spp. and *Salix* spp. are common along streams and meadows. In the lower mountains sometimes extending into the

desert, running streams or cienegas are lined in addition by *Platanus occidentalis*, *Juglans*, *Fraxinus* and *Cupressus arizonica*. Upland species of one zone may extend down into the next lower zone along watercourses and canyons, e.g. *Quercus* spp. may grow down into the desert in such habitats. *Sporobolus wrightii* and *Hilaria mutica* occur along periodically flooded alluvial areas in the southern grasslands, while *Agropyron smithii* fills a similar niche in the north. Where groundwater is shallow, phreatophytes such as *Prosopis* or *Tamarix* may form dense stands.

VEGETATION CHANGES

Rangelands of the Southwest are not only quite diverse spatially due to differences in elevation, geology, climate and other factors but also have changed considerably in time. These changes are of two basic types, the short-term cyclic changes related to dry or wet years, and longer-term, more permanent modification of vegetation and soils due to climatic change and/or land-use influences. Both types have a strong impact on range and wildlife management strategies as well as research needs and interpretation of research results.

Changes Due to Weather

The concept of normal or average precipitation and, to a lesser extent, temperature has less meaning in the Southwest than in more stable and predictable climates. Productivity and occurrence of plant and animal species is often influenced more by extremes of temperature or moisture, and the time elapsed since those extremes, than by average conditions. A few examples may illustrate this point.

Grass production on desert grassland ranges in the 250-300 mm rainfall zone may vary from 55 k/ha in dry years to 280 k/ha in wet years, or by a factor of 4 to 5 times. Annual grasses fluctuate more than perennials (Martin 1975). Several consecutive years of dry weather may reduce perennial grass populations by 50 to 60% even on ungrazed ranges. Several years may be required for range production to recover after such periodic drought, and there is some evidence that recovery is faster on moderately grazed ranges than on ungrazed ranges (Martin 1975, Paulsen and Ares 1962). Rodent populations are also highly correlated to rainfall.

Not only does productivity of range ecosystems vary with weather but the composition and structure of communities also is affected by time elapsed since extreme weather effects. Unusually wet winters may produce a high population of *Happlopappus tenuisectus* or *Gutierrezia* spp. which then may persist several years until drought, insects or other factors reduce the population (Martin 1975, Jameson 1970). There is some indication that *Opuntia fulgida* also follows a cyclic pattern, though the reasons are not known (Martin and

Turner 1977). It has been well-documented that the age structure of Pinus ponderosa forests in Arizona is related to infrequent occurrence of years with adequate spring moisture and warm temperatures which allow seedling establishment (Cooper 1960, Schubert 1974). Such random establishment of long-lived species may set in motion a succession of reactions in other plants and animals which alter the effects of subsequent weather or management.

Historical Changes

In addition to, but not necessarily independent of, the kinds of cyclic, weather-related changes noted above have been widespread, more permanent changes in plant communities and soils which have been documented since the late 19th century. Such trends have mainly involved increases in woody plants such as Cercidium spp., Prosopis spp., Larrea tridentata, Acacia spp., Juniperus spp., Pinus spp. and many others, as well as widespread arroyo cutting in alluvial valleys. Streams which once contained fish and supported moisture-loving plants are now dry channels which only run for short periods. These changes have occurred in most of the life zones but are most pronounced in the areas transitional from desert to forest (Harris 1966). Although the changes are well-documented, the reasons are not well understood. Several hypotheses, discussed below, have been advanced.

Overgrazing

Both the increase in woody plants at the expense of herbaceous plants, especially perennial grasses, and the formation of arroyos were first noted in the period of about 1885-1905. Early writers, such as Thornber (1910), Wooten (1908) and Griffiths (1901) noted these changes and, since they were generally coincident with large scale introduction of livestock by Anglo-American ranchers, they concluded that the heavy and uncontrolled grazing of that period was the cause. This conclusion is still widely accepted by some as the major, or only, reason for the changes observed.

Proponents of this theory argue that in the former grassland communities competition from perennial grasses was sufficient to prevent shrub encroachment. Overgrazing weakened the vigor and cover of grass allowing entry of shrub seedlings. Reduced grass cover, soil compaction and livestock trails led to increased runoff which caused sheet and gully erosion. It has been observed that cattle disseminate seeds of Prosopis in the feces and that dense perennial grass can greatly reduce establishment of Prosopis and Juniperus seedlings (Glendening and Paulsen 1955, Johnsen 1962).

Other people have argued that while overgrazing may have contributed to the observed changes it was neither a necessary nor sufficient reason for such changes. Grass cover may be reduced 40 to 90% by drought (Cable 1959, Herbel,

et al 1972), and shrub seedlings can establish even in dense grass stands in wet years (Johnsen 1962). Shrub seeds are widely disseminated by wildlife as well as livestock, while some shrubs not consumed by livestock, such as Larrea, have also spread. Arroyo-cutting is known to have occurred in earlier periods before the introduction of livestock. The current cycle of arroyo-cutting and shrub invasion occurred at the same time in northern Mexico as in the Southwestern U.S., although cattle were introduced in large numbers earlier in Mexico (Hastings and Turner 1965). Shrubs have been shown to continue to invade areas under long-time protection from grazing (Buffington and Herbel 1965) or which have never been grazed (Hastings and Turner 1965).

Cessation of Fire

Griffiths (1901) attributed shrub increase to lack of periodic fire. Humphrey (1958) was also a strong supporter of this hypothesis. According to them, fires caused by lightning and set accidentally or deliberately by the Indians favored grassland over shrubs. The occurrence and extent of fires was greatly reduced by livestock grazing, which reduced the fuel, and fire prevention and control by ranchers and government agencies. There is good evidence that fire frequency of about 8 years was a factor in maintaining open pine-bunch-grass forest prior to exploration and settlement (Weaver 1951, Cooper 1960). However, some have argued against this mechanism for the grasslands on the ground that the vegetation in some areas was too sparse to burn or that there is no documented evidence that extensive fires actually occurred in these grasslands (York and Dick-Peddie 1965, Hastings and Turner 1965, Buffington and Herbel 1965).

Climatic Change

Hastings and Turner (1965) presented pictorial evidence of a generally upward shift in life zones from the desert to the encinal. They concluded that there was a change to hotter, drier conditions since the late 19th century. Others have found no evidence of climatic change in this period (Martin 1963). Some studies have suggested that the period of 1870-1904 embraced several severe droughts followed by a high incidence of exceptionally wet years from 1907-1926. This sequence, along with a tendency to fewer light and more heavy rains, could have weakened grass cover and increased storm runoff resulting in shrub invasion and erosion (Leopold 1951, Cooke and Reeves 1976, Stockton and Fritts 1971). Such changes may have been aggravated by heavy grazing.

Conclusions

It is difficult or impossible to establish causal relationships between observed changes in vegetation or soils and natural or man-caused environmental changes. Combinations of factors

are probably involved and the combination may vary from place to place. Both long-term and short-term vegetation/soil changes have a major influence on management strategies and research needs for southwestern rangelands.

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The Social Dimensions of Rangeland Management¹

T. E. Downing and P. F. Ffolliott²

INTRODUCTION

A social scientist's contribution to this workshop should highlight the socioeconomic context of rangeland management problems and emphasize that the improvement of the human condition is a crucial part of rangeland development programs. Being an interdisciplinary gathering, including cattle developers, wildlife assessors, and rangeland managers, you hold an interdisciplinary perspective, as is evident in your invitation for us to speak here today. Also, given the binational experience of the group, it seems unnecessary to repeat the general differences and similarities between the United States and Mexico. Instead, we shall emphasize a handful of social and economic facts concerning the northern Mexico and southwestern United States rangeland situations which must be considered if either management or technological solutions to rangeland management problems are to be transferred across the border in either direction.

In his classic introduction to the topic, Heady (1975) stresses that:

"Rangeland management is a land management discipline that skillfully applies an organized body of knowledge known as 'range science' to renewable natural resource systems for two purposes: (1) protection, improvement, and continued welfare of the basic range resource, which may include soils, vegetation, and animals; and (2) optimum production of goods and services in combinations needed by mankind."

After presenting a basically ecological model for achieving these objectives, Heady realistically assesses the practical difficulties facing an "on the ground" manager.

"Rangeland professionals provide...knowledge to the actual managers and administrators of rangeland. The exchange of

information between the providers and the users has been slow. Many scientists have neither the interest nor the time to sell their products. Range managers, as a group, often are more concerned with what can be done biologically than with what the land managers choose or can afford to do. The traditions of rangeland use change slowly for these and many other causes. One might ask the question: If these practices are so good, why haven't they found wider application?"

Heady answers that each recommended practice must be considered within its larger context, that is, within its biological, social, political, and economic context. Without considering the larger context, Heady, you, and we know that reasonable, ecologically sound management and technological solutions may never be implemented.

THE SOCIAL GROUPS IN A RANGELAND SITUATION

An analysis of the larger context begins by realizing that a discussion of rangeland management concerns the interaction of three populations: (1) the rangeland users (government agencies, private ranchers, ejidatarios, or otherwise); (2) professional rangeland managers; and (3) nonranchland oriented populations whose actions influence the actions of the preceding groups. We assume that Heady's reference to the "larger context" refers to the latter population, including the institutions, regulations, history, and economic systems in which rangeland managers and rangeland users are enmeshed. Each of these populations has certain knowledge and beliefs concerning rangeland management, which, right or wrong, must be considered in any realistic management problem. An objective of rangeland science is to increase the overlap between the rangeland scientists' knowledge and the users' knowledge. This overlap, which we shall call the "area of influence," represents those ideas and management criteria known to be scientifically valid by the rangeland managers and accepted as "standard operating practice" by the rangeland users. This area of influence will be greater among some combinations of rangeland scientists and users than among others. Moreover, the "area of influence" implies a two way exchange of knowledge, for it is also the area of the rangeland managers' knowledge of the users' information and knowledge.

Concerning all three populations, there are certain socioeconomic facts that must be considered if we are to have any meaningful actions.

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FACTS CONCERNING SOCIOECONOMIC CONTEXT

Fact: Although the rangelands of the southwestern United States and northern Mexico show great ecological similarities, the socio-cultural and economic contexts of rangeland use differ.

Northern Mexican and the southwestern United States share the common characteristic of having the majority of their lands suitable for rangeland (Table 1), or as a nonrange oriented outsider might quip, "Suitable for little else but rangeland."

Despite this similarity, land tenure (the question of who controls what land) seems to vary between the two countries. On the northern side of the border, considerable landholdings are "managed" by government agencies. Grazing lands make up about 85 percent of Arizona's 72 million acres (Hillman 1972). Yet, private tenure over these lands is restricted. Less than 16 percent of the land is in private hands, while the Federal and State governments control about 60 percent of the land. Indian reservations hold the remaining 27 percent. Under such circumstances, the "management" of the public domain has become a major problem and the rangeland management discipline, itself, offers an institutional and academic solution to this problem.

In Mexico, on the other hand, if we consider ejido lands to be privately controlled, very little rangeland appears to be under federal control. Rangeland scientists in Mexico often do not have contact with the problems of maintaining the public

domain in the same way that scientists from the United States do. Thus, the special relationship that exists between rangeland managers and the federal government in the United States should not be expected to occur in the Mexican situation.

Moreover, the United States range situation is strongly influenced by the presence of "interest groups" whose actions toward public and private rangeland use play an active role in the decision-making process. The governmental decision-making processes which favor public-participation and hearings are distinct from the decision-making processes in Mexico. Because of its inherent ecological basis in biology, rangeland managers are often identified with the "environmental movement," which may or may not be related to their political tendencies. Mexico also has a nascent concern for its renewable natural resources, represented institutionally in such centers as the Subsecretary of Forestry and Wildlife, the Institute of Ecology, and the Center for Ecodevelopment.

The relative capital intensity of rangeland management in the United States and Mexico also appears to vary. The high costs of labor in the United States favors more capital intensive solutions to management problems, while Mexico displays a less expensive labor profile (Table 2).

Observation reveals the United States prefers fencing (which is capital intensive) as opposed to ranch hand control of herd movement in Mexico (a more labor intensive solution to the same problem). This difference in the labor intensity of management solutions is a critical variable for consideration in proposed technical and management oriented

TABLE 1: COMPARISON OF RANGELAND USE AND LABOR FORCE IN ARIZONA, NEW MEXICO, CHIHUAHUA, NUEVO LEON AND COAHUILA

STATE	ANIMAL POPULATION			Grazing	LAND % of total land (in 1000km ²) ⁽⁶⁾	TOTAL LABOR FORCE in Agriculture	% of labor ⁽⁹⁾ force in Agriculture
	Sheep	Cattle	Goats				
	in (1000)						
ARIZONA	340 ⁽¹⁾	807 ⁽²⁾	na	250 ⁽⁴⁾	85.3	28,000 ⁽⁷⁾	3%
NEW MEXICO	595 ⁽¹⁾	1,316 ⁽²⁾	na	250 ⁽⁴⁾	79.6	26,000 ⁽⁷⁾	5%
SONORA	44 ⁽³⁾	1,664 ⁽³⁾	85 ⁽³⁾	135 ⁽⁵⁾	73.7	109,377 ⁽⁸⁾	39%
CHIHUAHUA	386 ⁽³⁾	3,110 ⁽³⁾	305 ⁽³⁾	159 ⁽⁵⁾	64.3	151,498 ⁽⁸⁾	36%
NUEVO LEON	237 ⁽³⁾	682 ⁽³⁾	601 ⁽³⁾	53 ⁽⁵⁾	82.3	85,149 ⁽⁸⁾	17%
COAHUILA	367 ⁽³⁾	839 ⁽³⁾	764 ⁽³⁾	138 ⁽⁵⁾	91.6	85,760 ⁽⁸⁾	29%

- Sources: (1) USDA Agricultural Statistics (1980) - Includes stock sheep only
 (2) USDA Agricultural Statistics (1979) - Includes stock cattle only. The average number of cattle on feed for the 4 quarters of 1979 was subtracted from the total number of cattle to get the stock cattle.
 (3) Anuario Estadístico de la Población y Producción Pecuaria de los Estados Unidos Mexicanos, Secretaría de Agricultura, 1977. (Dairy cows are also included in the cattle data).
 (4) Data obtained from An Assessment of the Forest and Rangeland Situation in the United States, by USDA, Forest Service, 1980 (FS-345). The data includes the total forest and rangeland grazed in 1976.
 (5) The grazing area in Mexico was calculated on the basis of Landsat photographs published by SARH, 1978. The categories considered in the grazing lands (grassland and shrubs) were Pastoral, Matorral, Vegetación Halofila, Mezquital, Chaparral, Nopalera, and Izetal.
 (6) The percent grazing land of the total land area was calculated from the sources indicated in (4) and (5).
 (7) USDA Agricultural Statistics (1980) - Includes the annual average number of total workers on farms for 1979.
 (8) Censo General de Población (1970) for Sonora, Chihuahua, Nuevo Leon, and Coahuila.
 (9) The percent of farm workers in the total labor force was calculated from the sources indicated in (7) and (8).

TABLE 2: INTENSITY OF HUMAN/ANIMAL USE OF RANGELANDS IN MEXICO AND U.S.

STATE	ANIMALS PER FARM WORKER ⁽¹⁰⁾			ANIMALS PER SQUARE KILOMETER OF RANGELAND ⁽¹¹⁾		
	Sheep	Cattle	Goats	Sheep	Cattle	Goats
ARIZONA	12.1	28.8	na	1.4	3.2	na
NEW MEXICO	22.9	50.6	na	2.4	5.3	na
SONORA	0.4	15.2	0.8	0.3	12.3	0.6
CHIHUAHUA	2.5	20.5	2.0	2.4	19.6	1.9
NUEVO LEON	2.8	8.0	7.1	4.5	12.9	11.3
COAHUILA	4.3	9.8	8.9	2.7	6.1	5.5

Sources: (10) The animals per farm worker was calculated from the appropriate data and sources indicated for Table 1.

(11) The animals per square kilometer ($247.1 \text{ acres} = 1 \text{ km}^2 = 100 \text{ hectares}$) was also calculated from the data in Table 1.

decisions. Technologies acceptable on one side of the border will prove economically untenable on the other side.

The institutional supports for rangeland management are also distinct. In the United States, rangeland managers have a professional responsibility to maintain a renewable natural resource, often with the objective of protecting the public domain.

Implications: rangeland management solutions which appear ecologically and economically defensible on one side of the border may not be on the other side. Each technological and management scheme must be filtered through a sociopolitical and economic screen before the feasibility of the solution is evaluated.

FACTS CONCERNING RANGELAND MANAGERS POPULATION

Fact: Exchanges between the two federal governments and range managers is distinct.

Rangeland management in the United States developed in a specific, task-oriented setting (the protection and management of the public domain). The rangeland users in Mexico, who control most of the rangelands have not created a strong demand for rangeland management, and many of the smaller users, who need the rangeland manager's knowledge, are not even aware of the existence of this scientific endeavor.

Implications: the sociopolitical influence of rangeland science in the United States has been and will be distinct for the rangeland scientist in Mexico and the United States.

FACTS CONCERNING RANGELAND USERS

Fact: The rangeland animals emphasized in Mexico and the United States differ.

The southwestern United States shows a predominance of cattle; northern Mexico has not only cattle, but also a high proportion of sheep and goats. Rangeland management, in many cases, is animal specific, since the grazing patterns, browse preference, herd behavior, are distinct for each species.

Implications: therefore, a sophisticated rangeland management solution will have to show sensitivity to the difference in user preference for different animals.

Fact: We have poor information as to precisely how users in either country manage their rangelands.

As we were preparing this paper, we searched for detailed descriptions of how the two countries manage their rangelands. The search was disappointing. However, we can assume that MOST RANGELANDS ON BOTH SIDES OF THE BORDER ARE NOT MANAGED BY RANGELAND MANAGERS.

How much of the rangelands of either Mexico or the United States is actually influenced by rangeland management? This question arises over and over again in discussions, such as we will be having during the next few days. We cannot answer this question any more than you can, but, there appears to be a general consensus that the overall impact of rangeland management science is less than desirable. Perhaps our modest contribution to this question might be to rephrase it. Rather than searching for an answer in acres or hectares or by different kinds of land types, we should realize that we are talking about the area of influence. Management success should not be measured by areal influence, but by the influence of human knowledge, and, we should ask instead, how effective has the penetration of scientific knowledge into the decision-making processes of those who control rangeland use been. Such a perspective changes how we determine the "score of the game", it is not to be measured in "acres managed" but rather in "heads (of people, not animals) influenced."

Rangeland management seldom operates in a vacuum. Although most rangelands are "managed" without the advantage of the organized body of knowledge and scientific principles characteristic of rangeland science. Knowledge of the existing system can only be gained through observation and face-to-face interviewing with rangeland peoples. Windshield tours are not sufficient to understand the complexities of a rangeland management system. We also have little idea of how rangeland peoples perceive their rangeland resources and the management sciences that attempt to provide additional information into their complex decision-making process.

Fact: A great deal of practical knowledge concerning rangeland conditions resides in the collective minds of ranchers.

All rangeland managers know that it would be foolish to suggest that their discipline, or even all the academic disciplines, have exclusive information on rangeland management. Much of what is known about specific rangeland conditions and rangeland management practices resides in the collective heads of hundreds of bright rangeland users (cowboys, ranch owners, operators, herders, etc.). Unfortunately, very little of this "folk" or "practical" knowledge is systematically collected and organized. Nonetheless, much of this information on local range conditions, animal behavior, and microenvironmental conditions can be recovered. Some of it will prove of minimal use to hard scientific investigations, while other information will assist in the development and testing of hypotheses. To deny the importance of this local level knowledge is to deny the value of experience itself, a denial which few of us who are nearing out middle age would dare support.

FACTS CONCERNING SOCIAL SCIENTISTS WORKING WITH RANGELAND PEOPLES

Fact: Social scientists have limited ability.

Without further research on how to predict the impacts of new rangeland management practices on human populations, however, we are beginning to understand how the above might be done. Much of human social life revolves around work related activities. Insofar as a social scientist understands the details of a new technology, he can estimate what types of social arrangements and conflicts will accompany a rangeland development plan. A few of the social scientists have extensive experience in addressing the rangeland development problems of traditional herders, cattlemen, and nomadic groups (Johnson 1979, Spooner 1973, Al-Gain n.d., etc.) Moreover, the ranks of social scientists interested in rangeland problems is increasing (Downing and Sayers 1979). Evidence which these investigators are collecting, thus far, suggests an important change in perspective on "human factors" in the rangeland production process. We are beginning to realize that sociocultural settings not only

present problems, but also solutions to rangeland problems. The view that sociocultural behaviors are obstacles has to cease. Social organizations solve problems. The cutting edge of contemporary social scientific investigation is to search for technologies and management schemes that utilize the internal strengths of social systems, rather than seek creative ways to circumvent social traditions (Downing 1981).

Implications: social scientific research on rangeland problems is undergoing constant evolution and development. The current cutting edge of the social sciences consists of merging the knowledge that social sciences have of the human/animal/environmental relationships, based primarily on the modeling of traditional people, with the necessities of modern rangeland development.

RECOMMENDATIONS

Based on the above perspective, rangeland management needs the following research and cooperative work during the immediate future.

1. Collect baseline data on actual use of rangeland in both northern Mexico and the southwestern United States. These data should focus on, but not be limited to, the following information: land tenure/use; grazing patterns, especially seasonality; herd composition; market participation; labor/capital costs; production functions for different types of operations.

2. Integrate the above information into synthetic regional portraits of major rangeland and wildlife regions. The collection of additional statistics is necessary, but this alone is not sufficient for rangeland management. Some social and economic scientists are gifted with the ability to take masses of data and synthesize this information into an integrated, global overview of the rangeland situation, identifying major constraints, conflicts, and potentials of a region that seems to influence human behavior again and again. An excellent example of this ability is John Bennett's work on *The Northern Plainsmen* (1969), Wally Goldschmidt's (1947) early study of Californian agriculture, and Edward Spicer's (1962) description of early southwestern United States' development in *Cycles of Conquest*. These synthetic portraits, when properly done, not only provide us with an overview of the general conditions of natural resource utilization and human groups who compete for resources, but also allow the actors involved in management problems to gain a perspective on the motivations and objectives of other interest groups. The problem here is that few scientists are intellectually qualified to write such syntheses.

3. Review the experience of the United States with regard to the Apache and Navajo Indian Reservations. Although it is relatively easy to claim that rangeland managers and government officials in the United States have "considerable experience" working with traditional peoples on the large Indian reservations that dominate the southwestern

United States, it is much more difficult to state precisely what this "experience" is and to organize it in a manner that may help the cross-cultural transfer of science and technologies between rangeland scientists and traditional peoples on both sides of the border. The collective experience of rangeland managers over four or five decades lays dormant in government files, field reports, and the heads of participants in these developments. A relatively inexpensive project that would have considerable payoffs would be to systematically organize and collect this information in a format that could be used as guidelines for future developers.

4. Develop cooperative training ventures. The fact that the specific rangeland situations of northern Mexico and the southwestern United States differ should not be discouraging. The socioeconomic differences are large enough that we may expect that a great deal of the specific training we carry on, on either side of the border, needs more "fine tuning" to the situation on the other side. The best method for achieving this cross-cultural understanding is for close cooperation to occur between faculty, students, government officials and other professionals on both sides of the border. Very few range management schools in the United States are equipped to prepare Mexican graduate students for working with their native institutions and rangeland users. Closer contact with the Mexican situation and the Mexican faculty and government officials could assist the United States' faculty and schools in leading Mexican students in the proper direction. More directly, it would be of considerable assistance to have Mexican officials and faculty hold visiting appointments in schools in the United States so that students in the U.S. could become familiar with a more international perspective. Likewise, if rangeland scientists in the United States are to develop management tools with more cross-cultural applicability, they must become more intimately acquainted with rangeland problems outside the southwestern United States. Leaves of absence, cooperative research endeavors, and sabbaticals taken by United States' faculties and government officials in Mexico could greatly improve the management perspective of both countries. Finally, Mexican government officials or faculty would not wish to adopt a rangeland management solution that is inappropriate for the conditions in Mexico, nor would they wish to avoid certain useful solutions which might be transferred without any accompanying negative disruptions. With-

out close cooperation and an understanding of the important differences, as well as the similarities between the two countries, such errors cannot be avoided.

SUMMARY

As long as humans manage animals and adjust their management techniques to fit human goals and needs, rangeland management will require a social dimension, a perspective of the "larger context." At present, we are just beginning to understand how to grapple with this question of the "larger context." One simple lesson that anthropologists have learned and taught is that a comparative perspective not only increases understanding of another culture, but also of one's own. The development of a cross-cultural, comparative perspective is one of the primary reasons for this workshop.

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Current Status of the Natural Resources in the Northwest of Mexico¹

Eng. Rafael Aguirre M. and Eng. Donald Johnson G.²

Abstract.--The northwest of Mexico is made up of the States of Baja California, Southern Baja California, Sinaloa, and Sonora. They occupy an area of more than 38 million ha, of which 5.79% is agricultural, 65.24% is devoted to cattle raising, and 28.97% is not utilized either for agriculture or for cattle raising. In spite of the high technology applied to agriculture in that region, production is not increasing; there are problems with salinity, decrease in the number of aquifers, and erosion due to inefficient management of soil and water.

In cattle raising also, mismanagement of the range resource has brought about erosion, vegetation destruction, disappearance in some cases of species endemic to the area, sedimentation in the reservoirs, desertification, low animal production, drastic changes in native vegetation, invasion of non-forage species, and, in years of drought, cattle mortality due to thirst, famine, or poisoning. Other economic activities which, because of lack of control, harm or destroy natural resources are: mining, fishing, and tourism, including the construction of hotels. There is a need for adequate programs for better management and control of natural resources.

Sonora and Baja California have ongoing official State programs to control the utilization of resources, and for long-range planning of their conservation and improvement. But there is still a need for environmental education programs to make the public and the decision-makers aware of these needs.

The northwest of Mexico is made up of the States of Baja California, Southern Baja California, Sinaloa, and Sonora, forming the basin of the Gulf of California. Table 1 indicates the amount of land devoted to agriculture and cattle-raising in the area.

The natural resources of this area are its vegetation, where COTECOCA has identified 20 types of shrublands, 11 types of forests, 6 types of woodlands, 4 types of pastures, groups of halophytes and mangroves, its rivers, its beaches, its sea, its countryside, its wildlife, etc.

The human activities which affect these resources are:

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AGRICULTURE

Although the northwest of Mexico reportedly has 2,250,000 ha of agricultural land with irrigation, semi-irrigation and temporary irrigation, less than 2 million ha are being utilized in order to make good use of the available surface and underground water. The production of the zone has not exceeded 4.5 tons/ha as an average, and the ecologic cost of water/kg produced is rising. In spite of the high technology applied, the efficiency in management of water and soil is low, production costs have risen considerably, and production in general has been checked and sometimes has diminished.

Saline intrusion in districts that are irrigated by pumping from wells is increasing; the underground water reserves are being used beyond permissible standards, and the surface water is less as the irrigation reservoirs are filling up with sediment faster than was expected because of the mismanagement of the hydrologic basins and because of a lack of adequate management programs. This is partly demonstrated by the closure,

Table 1.--Shows land area used and not used for farming and ranching by state and by zone with corresponding percentages.

State	Agric. Area, ha.	% of total	Ranching Area, ha.	% of total	Area not used, ha.	% of total	Total
B.C.	226,420	3.23	2,309,280	32.94	4,475,600	63.83	7,011,300
S.B.C.	387,000	5.26	3,000,000	40.71	3,980,700	54.03	7,367,700
Sinaloa	800,000	13.77	4,960,000	85.38	49,200	00.85	5,809,200
Sonora	<u>830,000</u>	<u>4.48</u>	<u>15,000,000</u>	<u>80.89</u>	<u>2,713,000</u>	<u>14.63</u>	<u>18,543,000</u>
	2,243,420	5.79	25,269,280	65.24	11,218,500	28.97	38,731,200

due to saline intrusion, of 105 irrigation wells along the coast of Hermosillo which could irrigate 21,000 ha and by the purchase from foreign countries of agricultural products which we used to grow, and sometimes even exported.

As an example of the latter, table 2 shows the current situation in the State of Sonora.

CATTLE RAISING

Studies conducted by COTECOCA have proven that the majority of the ranches in northwest Mexico carry too many cattle, which results in destructive overgrazing. The more productive and desirable forage species are decreasing, and are being replaced by others of little or no forage value for either cattle or for larger hunted species or wildlife. The disturbance of the vegetative cover has caused accelerated erosion and a decrease in the equifers.

The range area in northwest Mexico consists of about 25 million ha and supports approximately 3 million animals. This represents an average stocking rate of 11 ha/animal unit, compared to a recommended rate of 27 ha/animal unit. This means that the average range overutilization in the northwest is 145%. By states, Sonora probably has the most severe problem: the average range overutilization there is 221%; by zones or by farms the range is from 5-3,000%. For example, the city of Pitiquito has 25% overutilization while Baviácora has 431%, and Tubutama has 1,100%. It is not necessary to describe here the effects that this overgrazing has on the ecosystems; a ride through the region would be sufficient.

Cattle raising, not only in Sonora but throughout the country, has been traditionally managed mainly as a simple way of life and not as an economic enterprise as it should be. This traditional management has caused a great deal of problems until now the resources are deteriorated, there are no investments, and cattle production has decreased considerably.

Another negative point is that, in order to alleviate social problems of employment, the land is distributed, and official livestock programs are developed in zones that either are not considered adequate for cattle raising, or are appropriate only for temporary use. Such is the case in the vast Sonoran desert and in 60% of the area of the Baja California Peninsula, where the vegetation cover does not exceed 7%, forage cover is less than 2%, and most of the waterholes and aquifers are saline. These areas would be more useful if they were utilized for the production of wildlife and/or for state or national parks dedicated to conservation, research, and education in order to preserve a vegetation and a wildlife which is unique in Mexico and in the world. What is now happening is that, many endemic species of wildlife and vegetation are becoming extinct because of the establishment of these kinds of programs, which in the long run not only will not remedy the social situation, but, if they fail, will create more economic and socio-political problems.

These two activities, agriculture and cattle raising, are the most important in northwest Mexico, and they utilize mainly the basic resources: land, water, and vegetation, but in an inefficient manner. Table 3 shows the average land and cattle production, and the expenditure in water per kilogram produced.

Other important activities which utilize and destroy natural resources are fishing, tourism, and mining. These activities are contaminating the Gulf and destroying in some cases the important inlets and bays, primary sources of the marine life in the Gulf. Another important activity, from an economic point of view, is mining, but if uncontrolled, it contaminates and ruins the regional ecology.

In general, the excessive utilization of natural resources in northwestern Mexico is causing drastic changes in the vegetation, accelerated desertification, large eroded areas, decrease of the aquifers, water shortage, and drought due to changes in the micro-climate of some areas, destruction of endemic vegetation, destruction of the scenery, and sometimes destruction of the wildlife as is the case

Table 2.--Annual hydrologic analysis in Sonora; collection, average use, and agricultural production.

<u>Annual Hydrologic Analysis in Sonora</u>				
State area	18.5 Million ha.			
Average annual drainage	4,800.0	Millions m ³		
Collection of average annual drainage	3,694.3	Millions m ³		
Available underground resource	1,500.0	Millions m ³		
Utilization of surface source	3,286.0	Millions m ³		
Utilization of underground source	2,300.0	Millions m ³		

<u>Collection</u>				
Dams	Actual collect. in million m ³	Ave. ann. drain. in million m ³	Collect. of sed. in million m ³	Actual sed. in million m ³
La Angostura	864,300		126,200	
P.E. Calles	3,000,000		600,000	
A. Oregón	2,989,200	2,591,000	500,000	
A.R. Cortínez	1,014,000	917,000	100,000	56,000 (56%)
A.L. Rodríguez	253,549	125,000	40,000	30,000 (75%)
Cuahtemoc	40,000	26,900	15,000	10,000 (66%)
I. Alatorre	28,000	34,400	1,600	
	8,189,049	3,694,300	1,382,800	

<u>Average Hydrologic Use</u>				
Concept	Million m ³ superficial source	%	Million m ³ underground source	%
Available	3,694,300	100.00	1,500,000 (1)	100.00
Agriculture	3,198,000	86.56 (2)	2,171,000	144.73
Cattle raising	30,000	0.81	2,000	0.13
Municipal	21,000	0.56	124,000	8.26
Industrial	37,000	1.00	3,000	1.20
	3,286,000	88.93	2,300,000	153.32

(1) Available underground resource.
(2) Of this percentage, 60% is utilized to generate electric energy.

<u>Agricultural Production</u>				
Cycle	Tons	Ha	Average ton/ha	Value in millions
1975-76	2,460,794	606,886	4.0	\$ 4,925.0
1976-77	2,346,688	609,481	3.8	9,061.7
1977-78	2,523,200	704,500	3.5	10,935.4
1978-79	2,450,614	779,125	3.1	14,329.5
1979-80	2,897,127	703,131	4.1	17,584.2
1980-81*	2,964,088	651,574	4.5	16,502.3

*Estimated.

Table 3.--AVERAGE PRODUCTION AND ECOLOGIC
EXPENDITURE IN WATER

Average production, ton/ha		Average cost, water/ kg produced	
Wheat	4.150	1,826	liters
Beans	1.200	4,000	
Corn	2.500	3,730	
Cotton	3.200	3,567	
Soybeans	1.950	4,729	
Chickpeas	1.800	3,259	
Saffron	1.900	3,815	
Sorghum	3.300	2,283	
Vegetables	15.300	530	
Beef	0.004	21,360	

with mule deer, bighorn sheep, masked bobwhite, white-tailed deer, etc. The latter two, enjoyment of the scenery and of wildlife, are two important tourist-oriented economic activities which both planners and the government have largely neglected.

There is a need for official and private programs concerning the adequate management and improvement of our natural resources, especially educational programs about the environment for the people, for the decision makers, and for the politicians. They often reach the wrong decisions because they are not aware of the actual or potential status of natural resources, because they lack counsel, and because they are trying to solve socio-political problems caused by overpopulation and scarcity of food.

It is estimated that, over the next 20 years, the demand for basic food products in our region

may increase 315%. Northwestern Mexico is actually self-sufficient in most basic land and cattle products, and even exports some of them, but if the abuse of natural resources continues, some may have to be imported.

Not everything is negative; the battle that was begun many years ago by Mexican and foreign technicians and scientists is being won as some ecologically sound governmental programs are put into effect. For example, this year in Sonora, a technically based program for integrated cattle raising is being developed; a new cattle raising law which will give priority to the management, conservation, and improvement of natural resources, declaring them public utilities, will be in effect; a Department of Ecology will be established within the State Office for Planning and Development; and biosphere reserves will be established. These activities will be discussed during this meeting. Something similar is happening in Baja California. In northwestern Mexico, the Advisory Association for the Environment of the Gulf of California has been established, made up of scientists, technicians, and Government officials to counsel the area's Governments in those projects and programs involving the management of natural resources.

In closing one might say that, although the current status of natural resources in northwestern Mexico is serious, it is not beyond repair. By establishing programs with adequate management, education, and willpower, we can recover that which has been lost.

Management of Wildlife and Its Vegetation in the Northwest of Mexico¹

Eng. Juan Jose A. Reyes Rodriguez²

Abstract.--Mexico established a legal framework for wildlife management, emphasizing its social, ecologic, and economic importance. Likewise, the need to study the activities of management within a Strategy for the Conservation of the Natural Resources of the Country (land, water, flora, wildlife, and countryside) is established. The general characteristics of the flora and fauna in northwestern Mexico included in the Nearctic Realm are discussed. Finally, the management activities and concepts for the establishment of the General Plan of Management for Wildlife Resources are outlined, indicating also the possibility of a joint effort.

GENERAL ASPECTS

As a renewable natural resource, wildlife is of utmost importance because of its ecologic, economic, and social function.

The administration of this resource has its foundation in the revolutionary nature of the Political Constitution of the Mexican United States, which in Article 27 states the Nation's patrimony concerning the natural resources of the country: This is to say that these are the elements that nature placed at the disposal of the people of Mexico as a nation emerging into a new era of development, of interest in general and the patrimony of the country. The regulatory laws have been derived from the fundamental charter, such as the Organic Laws of Federal Public Administration, of Forestry and Hunting.

For decades the esthetic aspect of wildlife has been studied, and it may be said that all social sectors consider it important; however, in many areas of the country wildlife species experience an unlimited exploitation, poaching, an uncontrollable commercialization and fundamentally an accelerated destruction of their habitat, that is to say of the areas bearing diverse types of vegetation which serves as food and cover.

This may be a result of ignorance as to how useful wildlife really is. For example, the ecologic importance of the extermination of predators, such as carnivores and birds of prey, as well as the destruction of the habitat, has a "boomerang" effect. The result is reversed when a greater number of rodents and grain-eating birds appear and greatly affect grain and vegetable production, with negative consequences in the production of food and generation of income.

Likewise, hunting and trapping activities generate an income which is an important economic reality that brings in 40-50 million pesos per year directly to the Government. If one considers the multiplying effect of that activity, or a "package" as is lodging, meals, gasoline, cartridges, and the industries that are created or enhanced, one is talking about an economic spread of hundreds of millions of pesos per year.

The importance of wildlife from a social point of view is primordial. Its function in rural nutrition has been a reality for many years, especially in the remote areas which rely on inexpensive animal protein. The cost would be represented by the man/hours dedicated to obtain it; thus deer, armadillo, tepezcuinte rodents, some worms and many other animals are food to many country people.

On the other hand, more than 10,000 families have jobs or carry on related activities such as hunting or trapping; this points out even more the importance of wildlife activities as a main social function.

The wildlife management activities that the Secretary's office has been carrying out are important, but the national needs go beyond those

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activities. One might say that the natural production of wildlife has been higher than the economic, technical, and human inputs expended. Because of this, it is time to work harder in the management of the country's wildlife, so that we will never reach the point when the natural production of the resource is no longer renewable, and has irreversible effects.

For this reason concrete steps are being taken to give more attention to the range, an important resource, given the watering down of already scarce funding in order to support and to get support from the General Representatives of the Secretaryship through the Offices of the Forest and Wildlife Program, and with the participation of different social sectors in the "State Wildlife Consulting Committees."

The activities in progress, as well as those being developed, are framed within the Strategy for the Conservation of the Natural Resources of the Country (land, water, flora, wildlife, and countryside) which constitutes the philosophical basis of the management of these resources with a practical application and, above all, in the long run with characteristics of permanency (Reyes 1980).

This strategy has the following basic purposes:

- 1) To determine what kind of a country we want future generations to inherit, taking into consideration the adequate utilization of natural resources, maintaining and improving their production and productivity; to organize the country with an ecologic basis in its land-cattle, urban, industrial, and touristic development.
- 2) To determine a specific policy in the executive branch of government for the conservation of the country's natural resources, making the necessary changes in the Global Development Plan, and having the nation acquire direct authority over the conservation units of public interest.
- 3) To establish alternatives for the scientifically proven utilization of renewable natural resources. It is fundamental to zone and delimit areas which should be utilized for land-cattle activities, and those areas for the management of wildlife. These could be permanent and would contribute to the Mexican Nutrition System through natural production in remote areas where land, water, and climatic conditions prevent or limit agricultural or cattle production.
- 4) To create new areas representative of natural ecosystems. It is fundamental to have areas with genetic reserves of flora and wildlife whose adaptation to the environment will allow for the genetic characteristics that science still cannot achieve in order to improve breeds and species. These areas would include Biosphere Reserves, Forestry Reserves, Protective Zones, Wildlife Sanctuaries, Wildlife Reserves, National Parks, and others.

THE NORTHWEST OF MEXICO

Dr. Miklos D. F. Uduardy (ICN 1975) in the Classification of the "Biogeographic Provinces of the World" for MAB Project 8, establishes a concept of hierarchy which is greater in scope than the previous classification of kingdoms (flora) and the regions (wildlife) which had been used, defining the Biogeographic Realm. This term is applied to an area the size of a continent or subcontinent with unified characteristics of geography, wildlife/flora/vegetation. It divides the world into eight Biogeographic Realms. Each realm is subdivided into Biographic Provinces, which are ecosystematic or biotic divisions.

Mexico is included within two of the Biogeographical Realms, the Nearctic and the Neotropical, forming a transition zone between the two. The first one includes the North-Central part, and the second one includes the South-Pacific-Gulf.

The area of common interest between the northwest of Mexico and the southwest of the United States is precisely in the Nearctic Realm, including five Biogeographic Provinces which are: California, Sonora, Western Sierra Madre, Chihuahua, and Baja California (see Map 1).

TYPES OF VEGETATION

In the area of our concern we find conifer and latifoliate forests, deciduous woods, chaparral, mesquite, rosette plants, microphyllous, thickets, crassulaceous plants, and in general, vegetation typical of arid or semiarid zones (see Map 2).

WILDLIFE

In the northwest of the country 470 species of mammals, 1,554 of birds, 332 of reptiles, and 55 of amphibians have been identified; the number of arthropods has not been determined.

The species which have been more relevant in recent years are those of interest to hunters, among them: bighorn sheep (Ovis canadensis), mule deer (Odocoileus hemionus), white-tailed deer (O. virginianus), coyote (Canis latrans), puma (Felis concolor), bobcat (Lynx rufus), antelope (Antilocapra americana), otter (Lutra annectens), javelina (Pecari tajacu), American bison (Bison bison), black bear (Ursus arctus americanus), and many more.

It has been estimated that the Mexican wolf (C. lupus), grizzly bear (U. arctus Nelsoni), California condor (Gymnogyps californianus), American bison, clapper rail (Rallus longirostris), and the antelope are in danger of extinction or almost extinct.



Tomado de:
Dr. Miklos D.F. Udvardy.

Map No. 1

ACTIVITIES OF MANAGEMENT

Out of a preservationist's spirit of not touching wildlife in order to maintain it, a tendency for poaching was created which unfortunately has not been able to be eradicated. Since the General Administration of Wildlife started the organized exploitation of bighorn sheep, mule deer, and white-tailed dove (*Zenaida asiatica*), clandestine activities have decreased, and there has been an increase in economic income and employment in rural areas.

The establishment of a General Plan for the Management of Wildlife Resources at a national level is being considered for 1981, within the Strategy for the Conservation of the Natural

Resources of the Country. This will include basically:

- a) The evaluation of wildlife resources, including habitat as well as animal populations.
- b) Ways of utilization for hunting and non-hunting activities.
- c) Techniques for wildlife management.
- d) Promotion and organization of the social groups who live and could live off the wildlife, as well as the groups which will use that resource for hunting or non-hunting purposes.
- e) Education of the rural and urban population so that they will appreciate these natural resources ecologically, socially, and economically.



Map No. 2

On the other hand, the integration of management plans by every state is fundamental in order to encompass all activities for habitat (vegetation, land, countryside) management, as well as animal population. For 1981 it is expected that 10 plans for management at State level will be developed, including the Baja Californias, Sonora, and Chihuahua, among others.

JOINT PARTICIPATION

Since 1975 the General Administration of Wildlife and the U.S. Fish and Wildlife Service have been meeting through a joint committee. Projects and sub-projects have been established with joint responsibility. The activities of the last few years have been mutually beneficial and have had satisfactory results.

The "wildlife" resource, not well understood and often mismanaged, represents a wide area for action including its basic research, as well as management, utilization, and protection,

since it includes not only animals, but habitat: land, water, flora, and countryside. The participation of institutions and of persons interested in the management of this resource is very valuable, and the joint participation which can take place within the constitutional and legal framework between countries and within each country, could bring about favorable short- and long-term results.

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Moderator's Comments: Research on Biosphere Reserves¹

Peter F. Ffolliott²

INTRODUCTION

The great environmental changes throughout the world over the recent decades have made it clear that a new dimension in conservation is required. This new dimension is needed to perpetuate the earth's living resources in all their variety, and to facilitate the proper study and understanding of the changes affecting these living resources for the future use and enjoyment of mankind. In large part, the international network of Biosphere Reserves within UNESCO's Man and Biosphere (MAB) Program is intended to contribute to this new dimension by the maintenance of ecological processes on an appropriate scale (UNESCO 1974). The underlying concept of Biosphere Reserves may be viewed as an approach to maintaining the integrity of biological support systems for man and nature throughout the whole biosphere (i.e., that portion of the earth's crust and lower atmosphere which contains life). As such, it involves conservation, restoration, and acquisition of knowledge for improving man's stewardship of both domesticated and wild countrysides.

In this session of the workshop, a series of presentations are offered to describe on-going and potential research opportunities on several Biosphere Reserves in northern Mexico and the southwestern United States. However, prior to these presentations it may be of interest to briefly review the objectives, characteristics, and types of Biosphere Reserves, and to describe the several desired kinds of research and monitoring activities to be undertaken on Biosphere Reserves.

OBJECTIVES OF BIOSPHERE RESERVES

As recognized by the International Coordinating Council (its governing body) for MAB, the primary objectives of Biosphere Reserves are:

1. to conserve for present and future use the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends;

¹Paper presented at workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States, Rio Rico, Arizona, April 20-24, 1981.

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2. to provide areas for ecological and environmental research (which is consistent with objective (1) above) including, particularly, baseline studies, both within and adjacent to Biosphere Reserves; and,

3. to provide facilities for education and training.

The above objectives are generally viewed as compatible. However, priorities among the objectives will vary with the nature of the Biosphere Reserve and the primary thrust of national MAB programs (Franklin 1977). For example, in some countries, establishment of Biosphere Reserves for conservation purposes will have priority, and research programs will have to be developed as quickly as possible. In other countries, particularly those with numerous existing conservation reserves, research and educational activities and the potential for their expansion may be more important in the selection of Biosphere Reserves.

CHARACTERISTICS OF BIOSPHERE RESERVES

The following statements by the International Coordinating Council for MAB summarize the main characteristics of Biosphere Reserves:

1. Biosphere Reserves will be protected areas of land and coastal environments. Together, they will constitute a world-wide network linked by international understanding of purpose, standards, and exchange of scientific information.

2. The international network of Biosphere Reserves will include significant examples of biomass throughout the world.

3. Each Biosphere Reserve will include one or more of the following categories: representative examples of natural biomes; unique communities or areas of unusual natural features of exceptional interest; examples of harmonious landscapes resulting from traditional patterns of land use; or examples of modified or degraded ecosystems capable of being restored to more natural conditions.

4. Each Biosphere Reserve should be large enough to be an effective conservation unit and to accommodate different uses without conflict.

5. Biosphere Reserves should provide opportunities for ecological research, education, and training. Further, they will have particular value as benchmarks or standards for measurement of long-term changes in the biosphere as a whole. Their existence may be vital to other projects conducted within the MAB program.

6. Biosphere Reserves must have adequate long-term legal protection. And,

7. In some cases, a Biosphere Reserve will coincide with, or incorporate, existing or proposed protected areas, such as national parks, sanctuaries, or nature reserves.

TYPES OF BIOSPHERE RESERVES

As mentioned above, the primary objectives of Biosphere Reserves include the conservation of representative and unique environments, research emphasizing environmental monitoring under natural conditions, research exploring impacts of anthropogenic factors on natural ecosystems, and education. Many Biosphere Reserves, particularly in North America, have been established with only a subset of these goals in mind (Johnson et al. 1979). However, a major conflict associated with single-purpose Biosphere Reserves is the frequent incompatibility between the conservation and manipulative research objectives of the MAB program.

To resolve conflict between different types of Biosphere Reserve utilization, protected "core" areas and "peripheral buffer zones" have been proposed (UNESCO 1974). As conceived, core areas and peripheral buffer zones were drawn as being contiguous in space. However, because contiguous buffer zones available for manipulative research do not always occur around conservation Biosphere Reserves, an extension of this concept, called Biosphere Reserve Cluster, has been developed for the United States. Within this latter extension of the concept, a conservation-oriented Biosphere Reserve forms the core of a Biosphere Reserve Cluster, with a contiguous buffer zone (where available) or a nearby experimentally-oriented Biosphere Reserve fulfilling the manipulative research objective (Johnson et al. 1979). Therefore, the cluster of Biosphere Reserves, together with fringe areas needed for future or supplementary investigations, fully addresses the objectives of a network of Biosphere Reserves while, at the same time, remaining compatible with existing land use patterns and administrative responsibilities.

Within the United States, examples of conservation-oriented Biosphere Reserves are the National Parks and Monuments, administered by the U.S. Department of the Interior, and the Wilderness Areas, administered by a variety of agencies under common Congressional guidelines (Franklin 1979). Examples of experimentally-oriented Biosphere Reserves include the Experimental Forests and Ranges of the USDA Forest Service, some Experimental Stations of the Science and Education Service (U.S. Department of Agriculture) and several land reservations under the jurisdiction of the U.S. Department of Energy.

RESEARCH AND MONITORING ACTIVITIES ON BIOSPHERE RESERVES

Many research studies are appropriately conducted under laboratory conditions, but most ecological knowledge arises from and is tested

by field research of natural or modified ecosystems. The establishment and maintenance of relatively large, diverse sites representative of major biotic provinces, as exemplified by the international network of Biosphere Reserves, provides investigative characteristics essential to the latter research endeavors (Risser 1979). To a large degree, Biosphere Reserves augment international research potentials from the standpoint of both individual sites and the collective array.

In summary, and before describing on-going and potential research opportunities on Biosphere Reserves in northern Mexico and the southwestern United States, it may be well to refer to several desired kinds of research and monitoring activities to be undertaken on Biosphere Reserves (UNESCO 1974):

1. long-term baseline studies of environmental and biological features, essential for management and for other research projects;
2. research designed to assist in determining management policies;
3. experimental or manipulative studies, particularly on the ecological effects of human activities;
4. environmental monitoring; and
5. study sites for other MAB-sponsored research projects.

The emphasis placed on different research and monitoring activities will vary with the nature of the Biosphere Reserve, the opportunities for continuation of existing research, and the availability of funding resources.

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Germplasm Conservation: Solutions in Mexico¹

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We live in an age of contradictions. One of the greatest is the growing interest in safeguarding flora and fauna, together with an also increasing rhythm of destruction of the ecosystems where these organisms live. Often antagonistic actions are generated by programs (or agencies) belonging to the same government: while one is planning actions to protect a species or a group of species, other can be destroying its habitat. In many occasions decisions which produce irreversible damage on germplasm richness are taken precipitately.

The massive extinction of species is a reality which has been pointed out for the global environment or for particular ecosystems in a great number of publications. The very magnitude of the crisis has led to the consideration of the need for a world wide policy, as well as national policies for the conservation of the germplasm as a first priority. We are far from the position of a few years ago which only contemplated two alternatives: either to keep nature intact, an alternative more romantic than realistic; or to accept the loss of a great part of the genetic heritage as well as of the ecological balance for the sake of development.

There are numerous similarities between the destruction of the cultural heritage and that of the genetic heritage. And though neither one is justified, there are differences in the way the general opinion reacts. For many years man has condemned any attack on his cultural heritage. The destruction of works of art, of language or his customs, of architectural or historical monuments is not tolerated. Any action of this sort is an act of aggression which provokes strong popular reactions. On the other hand, man looks on indifferently at the destruction of nature and at the disappearance of species which are part of his natural heritage.

The conservation of nature and germplasm, represented by the richness in plant and animal species, which was formerly only a scientific issue based on intuition and ethical considerations

for the future, is now a practical need of world-wide and national policies.

A country that destroys its ecological balance and its genetic heritage, just like a country that destroys its historical heritage is closing options for the future, and many leaders do not realize this. Sometimes in the name of a dubious temporary development, and sometimes out of ignorance or lack of initiative, a country that follows this line of actions is prolonging and perhaps increasing its dependence on the industrialized countries.

In a world burdened by overpopulation, by the unjust distribution of resources between nations and between men, and, in many cases by an imitative style of development which takes few provisions for the future, the conservation of germplasm should play a central role in any world wide plan regarding the protection of humanity's heritage.

We do not accept, not even do we justify any sort of damage inflicted on our cultural heritage. But culture is the work of man, works which many times have been well documented. In some cases where damages to the cultural heritage have occurred, it has been possible to reconstruct or repair them. In the case of genetic heritage the situation is totally different, as we are not able to remake any lost species. The disappearance of a plant or an animal is an irreversible fact. It is the end of an evolutionary process of thousands or millions of years. A process we are unable to reproduce and that is absolutely improbable that it should repeat itself.

If to avoid this loss, these ethical arguments plus the obligation of leaving a world at least as rich as we found it were not enough, then let us think in the financial waste that the loss of thousands of potentially useful species represents. From a purely practical point of view, this destruction is madness. Something is lost forever, a plant or an animal whose future usefulness we know nothing about: chemical substances with unknown applications, improvement of cultivated species, production of new materials, a great number of potential uses can be destroyed by ignorance or thoughtlessness. We are destroying a legacy without knowing its financial potential.

The main aim of Ecology nowadays is to understand the structure and the functioning of natural ecosystems, and also the biological phenomena that have determined their evolution and maintain their balance. This knowledge is fundamental not only for the development of the ecological theory, but

¹Synthesis of three papers presented at the workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States, Rio Rico, Arizona, from April 20 to April 24. Modified version of a paper published in *Folia Entomologica Mexicana*, 46, 1981.

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also in a wider sense for the balance between human society and the natural environment. Our capacity to decide on an adequate use of the biosphere, avoiding its deterioration, conserving its balance, designing strategies which make the exploitation of biotic resources compatible with the preservation of germplasm richness, all depend on this knowledge.

In countries like Mexico there is urgent need to recover the cultural and ethnic feeling of respect for plants and animals, which still persists in some isolated rural communities and which is the result of a long process of living together; the community adapting to a balanced environment.

Any social nucleus in expansion searches for better ways of life and because of this it modifies its environment. But this must not reach an irreversible point as far as deterioration goes, as this will imply the extinction of a good number of animal and plant species in that region. This is why all national or regional programs related to the use of natural resources should contemplate the conservation of intact areas where the germplasm or species richness is preserved.

The Bariloche Declaration points out that the socio-economic development of each country is the means by which to create the conditions where each human being can satisfy all his needs. These needs range from the basic ones such as survival, protection and security to those of creativity and self-expression. According to this conception, it is as important to increase the production of basic goods as to maintain our cultural and natural heritage.

The problem of the extinction of species is critical in the developing countries, particularly in those that are situated in the intertropical area. Undoubtedly both the possibilities and the problems of nature conservation in developing countries and in highly developed countries are totally different. In the former, the high rate of demographic growth, the increasing demand for satisfactors which goes together with the process of economic development, the very situation of social and cultural changes generate strong pressures on the natural areas not yet densely populated or exploited. Also, the national priorities are different. On the other hand, the problem of intertropical ecology is totally different to that of temperate or cold temperate countries, the richness of tropical ecosystems conceals the difficulty of managing them rationally.

In most parts of Mexico, and particularly in the tropical regions, the precarious financial situation and in many cases the socio-economic structure leads local populations to badly use or even abuse of the biotic resources. This is sometimes done going against traditional knowledge or customs. This phenomenon is far more marked when the peasant has not been born in the place, and, thus, lacks the traditional culture of that

area. A clash of interests appears between the economical imperatives of the moment, on one hand and the long range interest of the community as well as its customs on the other. This problem is common to all Latin America.

The problem of the disappearance of species can be the great deficit of the XX century. It is difficult to think of a problem of such deep implications as this and that is given so little importance by the general public. Many scientists have not perceived its true significance. Plant breeders have created vulnerable hybrids, while their ancestors disappear from the face of the earth. Medical researchers use laboratory apes as if the reserves of these species could provide an unlimited supply. Lumbermen, farmers, and planners continue to cut rain forests as if they were never to disappear. Lately some complaints have been heard, generally related to species that attract public attention like the whale and the dolphin, but, nevertheless, the problem of extinction not only exists but increases, while failures to change this situation pile-up, unseen and unheard of by the majority of the people and their governments.

SYSTEMS FOR THE PROTECTION OF GERmplasm

Various systems to reduce or avoid an ecological catastrophe are being developed or created: national parks, live museums or open air museums, protected areas and faunistic refuges where some species can reproduce themselves. The network of Biosphere Reserves promoted by UNESCO's Man and Biosphere Program (MAB) is the most broadest idea, based on a truly world-wide approach to conservation.

We shall refer ourselves to this last system and to some of the characteristics of the Biosphere Reserves which we have created in Mexico. We believe that these characteristics can be of interest to countries with socio-economic conditions similar to ours, that is, to the great majority of developing countries.

In the original plans and particularly in the way we have developed the Biosphere Reserves in Mexico, these incorporate both the local and national socio-economic problems, and the more general one of germplasm conservation. In Mexico we have insisted that long term protection of areas assigned to conserve germplasm intact is impossible to achieve unless we combine legal dispositions with the cooperation of the people that live in the area. The experience of six years of efforts does no more than confirm this approach.

Without this cooperation from the population of the area, without cooperation from the local authorities, the existence of the protected area is precarious, and the Reserve can become simply a lifeless decree.

Pressure on the last bits of land not yet exploited intensely is not only characteristic of Mexico. It happens in all developing countries.

This pressure cannot be put aside though it can and must be guided. It exists, and therefore it is fundamental to enlist the cooperation of the people most directly affected, i.e. the people living in the area.

It is this integral, humanist vision which makes Biosphere Reserves so unique: conservation of the national heritage for the benefit of humanity, particularly for the groups that live in contact with the protected areas and which are the ones who most need to learn how to use its natural resources properly.

A Biosphere Reserve is established to achieve a combination of aims that does not constitute the duplication of any other type of protected area. It can include another protected area, a part for example, without any need to change the legal status of the latter. In those countries where the park system works properly or in those where part of the park system has been established on a basis of ecological and fauno-floristic considerations many of the parks have turned into Biosphere Reserves without losing their characteristics or way of functioning because of it.

As we have repeated on many occasions, the Biosphere Reserves do not intend to compete or to affect existing protection systems (such as the national parks or the faunistic shelters). On the contrary, in Mexico they intend to create a smaller parallel system, to work in close contact with the existing parks and the authorities that are in charge of them.

BIOSPHERE RESERVES IN MEXICO

All the existing Biosphere Reserves in Mexico up to now have been created by the Institute of Ecology or else it has prepared the basic studies to support and justify their creation by a federal decree.

The Institute is a centre of scientific research belonging to the system of institutions of the Mexican Federal Government. It has legal recognition and its own funds. It is presided by the Secretary of Education and its board of directors is formed by the Director of the Consejo Nacional de Ciencia y Tecnología (CONACYT), the Head of the Departamento del Distrito Federal, the Governor of the State of Durango, and the Subsecretaría de Mejoramiento del Ambiente plus various distinguished Mexican and foreign scientists. Within the public federal administration it comes under the Secretaría de Programación y Presupuesto (SPP), as it is not only a research centre but it also advises the Federal and State Governments on ecological issues. The Secretaría de Programación y Presupuesto, under the technical supervision of CONACYT provides the Institute with an important part of its basic funds. It also receives an important contribution from the Subsecretaría de Educación Superior e Investigación Científica of the Secretaría de Educación Pública.

For the work in Durango and now, also for the studies in the new Reserves, it receives special help from the State Governments. It has also received grants for specific aspects of research from the UNESCO's MAB Program and the Ford Foundation, as well as from Mexican institutions such as the PIDER Program of the Secretaría de Programación y Presupuesto.

There are three formally established Reserves: La Michilía and Mapimí in the State of Durango, and Montes Azules in the Selva Lacandona in the State of Chiapas. The Institute has almost finished the preliminary studies for the creation of a new Reserve in the region known as El Pinacate. It is part of the Altar Desert or the Gran Desierto de Sonora. Further, the Institute has begun work for the creation of two new Reserves: one in the State of Tamaulipas, the second formed by the Islas Mariás in the Pacific.

MAPIMI BIOSPHERE RESERVE, DURANGO

Geographic Situation

This Biosphere Reserve is northeast of the town of Ceballos, on the slope formed where the States of Durango, Chihuahua and Coahuila meet. It is located between 26°29' and 26°52' latitude N, and from 103°32' to 103°58' longitude W. It is located in a well characterized physiographic area: The Bolsón de Mapimí which forms part of the Central Mesa of the northern Mexican uplands. The Bolsón de Mapimí is a basin crossed by small sierras which run more or less parallel, and which have at their base alluvial fans with rocky soils. These sierras are the uneven element within a continuum formed by the playas of the alluvial plains.

Extension

The Institute of Ecology owns 20 ha where the Desert Laboratory is found. This laboratory provides accommodation and working facilities for 40 people. Through cooperation agreements with ranchers and "ejidos", the Institute controls an area of about 100,000 ha.

Physical Characteristics

The dominant element is alluvium, formed by small rocks, gravel, silt and clay which originated during the Pleistocene. The outcropping of tertiary igneous extrusive rocks and volcanic rocks (rhyolite, andesite and basalt) can be observed in parts. There are isolated mountains and extensive interconnected playas. Altitude varies between 1 100 and 1 350 m. The climate is arid, with mean monthly temperatures varying between 11°C in winter and 28°C in summer. Mean annual rainfall is 230 mm, showing strong variation between years. Seasonal concentration of rainfall is very marked: around 80% of the annual total is received between June and September.

Vegetation

Floristically the Reserve is part of the Chihuahuan Desert, which is characterized by a great number of endemisms and a dominance of microphyllous shrubs which give the area its characteristic physiognomy. The dominant vegetation types are the rosette scrub or magueyal (*Agave* spp.), the succulent scrub or nopalera (*Opuntia* spp.), the spineless microphyllous shrub of creosote burn (*Larrea tridentata*) and the toboso or sabaneta range (*Hilaria mutica*) covers large areas.

Fauna

Pronghorn antelope (*Antilocapra americana*) existed in the area some years ago. At present a good number of big animals can be seen, like the mule-deer (*Odocoileus hemionus*), the desert tortoise (*Gopherus flavomarginatus*), the coyote (*Canis latrans*), the bobcat (*Lynx rufus*) and the mountain lion (*Felis concolor*). There is also a rich fauna of small mammals, birds and reptiles, which are adapted to the desert environment.

LA MICHILIA BIOSPHERE RESERVE, DURANGO

Geographic Situation

La Michilía is located on the Tropic of Cancer, from 23°25' to 23°30' latitude N, and from 104°15' to 104°21' longitude W. It is south-southwest of Durango City, 154 km away, on the Sierra de Michis which is part of the Western Sierra Madre. In the Southeast La Michilia lies the Sierra de Urica which marks the limits of the States of Durango and Zacatecas.

Extension

The Reserve has approximately 9000 ha of integral reserve (core area) which were bought by the Government of the State of Durango and are under the control of the Institute of Ecology. It has approximately 3 500 ha of buffer area.

Physical Characteristics

The geological base is formed by acid extrusive rocks, rhyolite and basalt. The topography is very uneven, particularly in the core area (Cerro Blanco). The deep soils are sandy-clay, while the soils in slopes are rocky. Even though permanent water courses are very scarce, the arroyos of el Laurd and el Temascal always have water. There is also a good number of marshes and temporary water reservoirs. Elevation varies between 2 250 and 2 850 m.

The climate is temperate subarid. Total annual rainfall varies between 500 and 700 mm. The annual mean temperature fluctuates between 12° centigrade and 28° centigrade, in the coldest month it varies between 3° centigrade and 18° centigrade, and in the warmest between 18° centigrade and 28° centigrade.

Vegetation

Pine-oak forest covers most of the core and buffer area of the Reserve. The association of *Pinus lumholtzii* and *Quercus rugosa*, with *Arctostaphylos polifolia* and juniper (*Juniperus durangensis*) is common. Other variants of the pine-oak association are formed by mixtures in different proportions of oaks (*Quercus chihuahuensis*, *Q. sideroxyla*, *Q. fulva*) and pines (*Pinus arizonica*, *P. engelmanni*, *P. ayacahuite*). In shallow soils with severe slopes, the vegetation becomes a chaparral formed by dense thickets of manzanita (*Arctostaphylos pungens*) and dwarfed, isolated individuals of oak species (*Quercus potosina*, *Q. rugosa*). There are also natural ranges with grasses (*Aristida* spp., *Panicum* spp., *Bromus* spp.) and forbs (*Senecio* spp. and *Stevia* spp.).

Fauna

The native fauna has decreased. The black bear (*Ursus americanus*) and the wolf (*Canis lupus*) have disappeared from the area, while the imperial woodpecker (*Campephylus imperialis*) is very rare. Other species are still abundant, like the white-tailed deer (*Odocoileus virginianus*), the mountain lion (*Felis concolor*), the javelina (*Dicotyles tajacu*), the coyote (*Canis latrans*) and the wild turkey (*Meleagris gallopavo*).

Zonation

The Reserve is divided into three zones, which include (a) the nucleus or core area, which is the zone of integral reserve at Cerro Blanco, (b) the buffer zone formed by small ranches and the ejido San Juan de Michis, characterized by bordering mountains and plains towards the north-east, east and southeast of the core reserve, and (c) the peripheral zone or zone of influence. The peripheral zone includes the Poanas valley and the town of Vicente Guerrero. This zone is located northwest of the Reserve, and is the most important agricultural centre in the surroundings.

EL PINACATE REGION, SONORA

Geographic Situation

Located in the northern extreme of the Gulf of California, the Pinacate region goes from the Adair Bay to the U.S. border. The study area, on which the Reserve zone will be defined, has an extension of 4 500 km². Its northern limit is the border line, the southern one is the 31°30' parallel; eastern and western limits are respectively, the meridians of 113°51' 06". This area includes part of the coastal ecosystems of the Adair Bay, of the dunes of the Gran Desierto de Altar, and the riparian communities of the Sonoyta River. It also includes the entire volcanic shield of the Sierra del Pinacate, one of the most extensive and striking basaltic formations in Mexico.

Physical Characteristics

The Pinacate volcanic shield has an extension of approximately 1 900 km². Nearly one third of large area is occupied by recent lava flows. This basaltic formation rests over a basement of plutonic and metamorphic pre-tertiary rocks and of cuaternary sediments. This rocky basement outcrops in parts forming small Sierras of gneiss, granite and schists. Towards the southwest of the Pinacate there exists a large extension of changing and fixed dunes, which buried in parts the volcanic shield and separate it from the Gulf coast.

Altitude ranges from sea level to 1 290 m at the Cerro Pinacate, the highest peak. Climatically, it is a warm desert. It shows no marked seasonality in rainfall, but there are extreme variations in temperature, both daily and seasonally. Mean annual rainfall is around 100 mm, but more than one year can pass with no rain. Mean temperature in the coldest month is 11°C, and 30°C in the warmest. Differences in temperature between day and night can be as high as 30°C.

Vegetation

The Pinacate area is located in the central part of the Sonoran Desert biogeographic region. Most of the study area lies in the Lower Colorado Valley subdivision. This is a microphyllous desert of which the Altar Desierto is the central part. In the northeastern part of the area, on the other hand, there are plant communities which are characteristic of the Arizona Uplands subdivision (succulent desert) with a lower proportion of annuals and a rich cactiflora.

The most important plant communities are the association of sahuaro and palo verde (Cereus giganteus, Cercidium microphyllum), the creosote bush (Larrea tridentata) scrub, the basalt associations characterized by ocotillo (Fouquieria splendens), elephant tree (Bursera microphylla) and torote (Jatropha cuneata), the dune vegetation, the halophyte communities in the Adair Bay coast, and the riparian associations in rivers and drainage courses.

Fauna

The pronghorn antelope (Antilocapra americana), the desert bighorn (Ovis canadensis mexicana) and the mule deer (Odocoileus hemionus) are important species in the area. Habitat destruction and chiefly hunting are responsible for the very low numbers in which these species are found at present. This is particularly serious in the case of the pronghorn antelope which is an endangered species. Coyotes (Canis latrans), foxes (Vulpes macrotis), jack-rabbits (Lepus californica, L. alleni) and rabbits (Sylvilagus audubonii) are very abundant. There are also mountain lions (Felis concolor), badgers (Taxidea taxus), gray foxes (Urocyon cinereoargenteus) and others. A very abundant

fauna of small rodents, birds and reptiles is widely distributed over the whole area. Its species composition varies according to the habitat and the plant communities.

LEGAL STATUS OF BIOSPHERE RESERVES IN MEXICO.

For fulfilling the goals that a Biosphere Reserve pursues, it is absolutely primary to establish a legal system which will guarantee the long term preservation of the Reserve as such. This legal system must also ensure the continuity of scientific research in the area.

The creation of the three Reserves established at present in Mexico has followed different patterns. This has resulted in marked differences in the administration and their achievements. Thus, while in the two Reserves in Durango research and promotion were started without a legal backing, in Chiapas the efforts were directed towards obtaining a presidential decree that declared the Reserve in the chosen area of Montes Azules. The decree was published in the Official Diary of the Mexican Federation the 12th of January, 1978. It declared the reserve area of public interest, established its limits and extension, defined the activities that can be realized and the areas where the only activities to be allowed are scientific and technological research, tourism and controlled use. Agricultural use and grazing were restricted to areas that had been clear-cut less than 20 years ago.

It is difficult to evaluate how much this decree (which is really a model in legislation) has had important effects in protecting the Chiapas rainforest and its fauna. The situation in Montes Azules is very complex, as it is indeed in all of the tropics in Mexico and Central America. Landless peasants migrate to the forests to search for new agricultural land. This process is made more critical by the pressure of extensive cattle grazing. This is a reality we must not overlook, and at least at a local level, actions must be taken to ensure the long-term success of the Reserve.

Eventhough we fully appreciate the complexity of the problem, we do believe that in Montes Azules there has lacked a scientific institution, with well-defined plans, to take charge of the Reserve. The Institute of Ecology made the studies that supported the decree (it even participated in the first draft of the decree), but did not keep control of the scientific research and the protection measures, as has been the case in Durango. There is a great contrast with Mapimi and la Michilía. In Montes Azules there isn't a well-structured program for protecting the Reserve, nor a plan for scientific research. There isn't either a stable budget or a support structure. This would not occur if a scientific institution promoted research and protection in the Reserve, and had to answer for its achievements to the State Governor and a Directive Council.

In Durango works were initiated in 1975 with two types of actions: (a) Scientific research (extended, in collaboration with the National Polytechnic Institute, to projects with a socio-economic component in the area of influence) and (b) Consolidation of the Reserves. To fulfill this second goal researchers tried to stay in the Reserves the longest possible time, combining basic ecological research with applied research of importance to local inhabitants. From the very first moment it was tried to arouse an interest in ranchers and ejido peasants on the research being done.

This is not an easy task, but if it is done with success there is no better system to guarantee the continuity of the Reserves. Thus, their creation did not appear as an act of authority but as a collective movement in which the Federal Government, the State Government, ranchers and ejido peasants participated. The Institute of Ecology coordinated these actions, with the authorization and under the direction of the Governor of the State. The continuity of our research is ensured, and it has never been interrupted.

Without any doubt, the continuous support of Dr. Héctor Mayagoitia Domínguez, at the time Governor of Durango, has been a decisive factor in the consolidation and success of the Mapimí and La Michilía Reserves. In 1978 the Government of the State finished the building of the Desert Laboratory at Mapimí, which was given to the Institute of Ecology as a donation. These facilities were inaugurated by the President of the Republic in the company of several ministers. Ranchers from Mapimí and La Michilía donated the land for the construction of the laboratories and residence, and donated a residence at La Michilía. All this guarantees for both Reserves the continuous presence of the coordinating institution, facilitating both research and teaching activities.

In order to carry out these activities it has been necessary to have a specific budget, which was very modest at first but has been growing with the Reserves. This budget has been granted by the Consejo Nacional de Ciencia y Tecnología and the Subsecretaría de Enseñanza

Superior e Investigación Científica, with additional funds granted by the Government of the State of Durango, the PIDER Program (Mexico) and UNESCO's MAB Program.

Once we had published results of our work, with a stable group of researchers working on each of the Reserves, an important level of international cooperation programs and excellent relations with ranchers and ejidos, we tried to consolidate the legal status of the Reserves. This was made through the establishment of two civil associations in March 1978. This system was chosen because it allows the participation of all sectors involved: federal and state governments, research institutions, ranchers and ejidos. In our case, the following institutions or persons participate: Government of the State of Durango, Subsecretaría Forestal y de la Fauna, Consejo Nacional de Ciencia y Tecnología. Institute of Ecology, Juárez University of Durango, MAB-UNESCO, ranchers and ejidos. The President of the association is the Governor of the State, and the Vicepresident is the Director of the Institute of Ecology. The Institute coordinates the scientific research and conservation programs. The core areas, bought by the Government of the State for conservation and scientific research, are under control of the Institute of Ecology with the supervision of the Government of Durango. The buffer area includes all the private properties that voluntarily cooperate with the activities and goals of the Reserve. Once the associations were created, the legislature of the State of Durango provided additional support by issuing a decree declaring the Cerro Blanco area an integral reserve.

The system created in Durango has shown to be stable in more than one aspect. When Dr. Mayagoitia was granted a leave to take charge as General Director of the National Polytechnic Institute, both the Provisional Governor, Dr. Salvador Gamiz, and in particular the new Constitutional Governor, Lic. Armando del Castillo Franco, have continued supporting the Reserves. With the support of the Subsecretaría Forestal y de la Fauna, legal protection has been completed through the issuing of two presidential decrees in July 1979 which declare officially Mapimí and La Michilía as Biosphere Reserves and forestry conservation areas.

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Multiresource Research and Its Implications to Management: The Beaver Creek Biosphere Reserve¹

Lawrence D. Garrett²

Abstract.--A multiresource research project on the Beaver Creek Biosphere Reserve is designed to create management guidelines utilizing integrated multiresource inventory and analysis techniques. The program has completed interim evaluations of multiresource responses to management treatments in ponderosa pine and pinyon-juniper types. Results from the research program, including single and multiresource treatment responses and analytical models are described.

INTRODUCTION

The Resources Planning Act (RPA) of 1974 placed specific emphasis on future planning, management and use of our natural resources. Emphasis was placed on effective monitoring of the production and use of natural resources, specifically those of the National Forest System.

The National Forest Management Act (NFMA) of 1976 presented in detail requirements to plan and manage the use and future productivity of our National Forest System. Specific guidelines are detailed regarding the need to develop standards and methodologies for improved management planning and monitoring of the National Forest System.

Legislators of NFMA emphasized a need to fully understand the broad implications of land management for multiresource outputs. Managers must now be capable of evaluating the tradeoffs to all impacted resources when attempting to implement the intent of NFMA.

To fully understand the tradeoffs involved when a management alternative calls to increase or decrease one particular resource requires understanding of the natural and social processes that result from making a change in a given land area.

The multiresource management research project at Flagstaff is designed to characterize biological and economic tradeoffs in multiresources that result from selection of differing management alternatives. The program, established in the late fifties, is informally referred to as the "Beaver Creek Program," referencing the Beaver Creek Experimental Watersheds and Biosphere Reserve from which many of the findings have been derived.

PROGRAMMING MULTIRESOURCE RESEARCH: BEAVER CREEK

Research Area

In-depth study of multiresource interactions relating to flora and fauna dynamics, water movement, etc. requires extensive pre- and post-treatment inventories of a rather large research area. In the case of water, entire small and large watersheds must be evaluated. To accomplish this in southwestern ponderosa pine and pinyon-juniper forest types, many small and large watersheds have been monitored in the Beaver Creek Watershed research area (fig. 1).

The Beaver Creek Watersheds are delineated by approximately 34°30' to 35° N. latitude and

¹Paper presented at "A Workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States." Rio Rico, Arizona, April 20-24, 1981.

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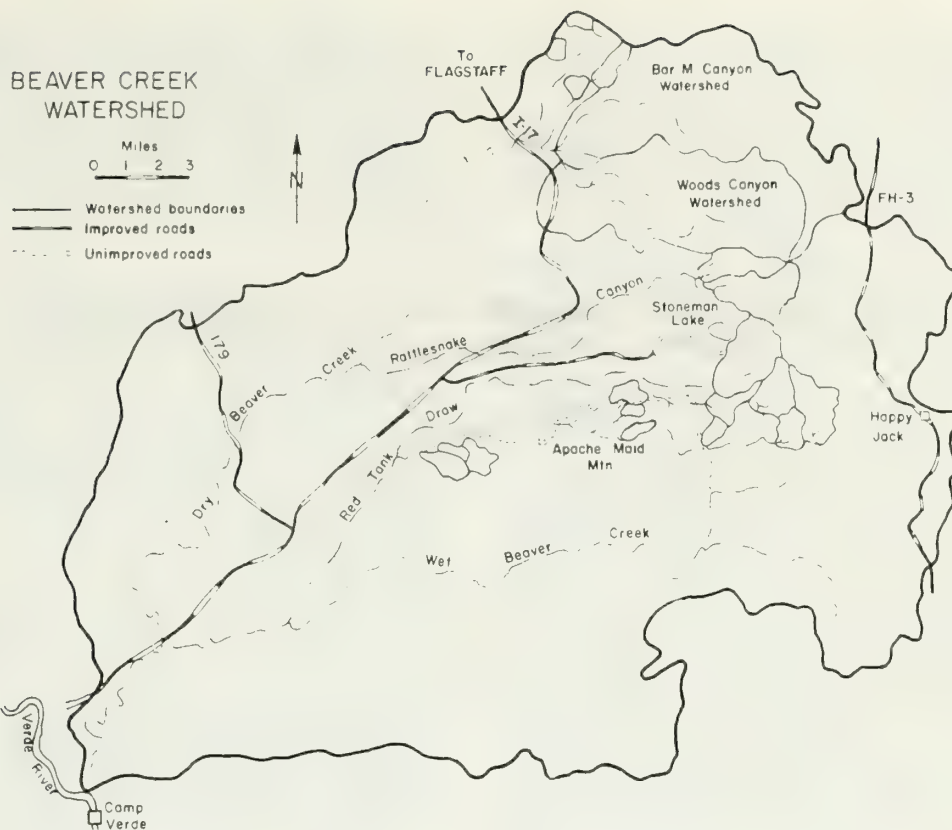


Figure 1.--The Beaver Creek Watershed Research Area and Biosphere Reserve.

111°30' to 112° W. longitude. The center of the watershed is 50 km south of Flagstaff, Arizona in Coconino and Yavapai counties. The general orientation of the watershed drainage is southwest with the major drainage into the Verde River. The Beaver Creek Watershed research area encompasses an area of approximately 111,300 ha (fig. 1).

A high plateau, sloping mesas and breaks, steep canyons, and valleys characterize the topography on Beaver Creek. The bedrock underlying the area consists of igneous rocks of volcanic origin; below them are sedimentary rocks of Kaibab, Coconino, and Supai formations.

Geology of the watershed was studied by Beus, Rush, and Smouse³, and Scholtz (1968). Their investigations identified, in addition to rock types, geological features such as faults and fractures that can be quantified and used in water prediction models.

The soils, developed on basalt and cinders, are mostly silty clay and silty clay loam less than 0.76 m deep. They are described in detail by Anderson, Williams and Creeze (1960) and Williams and Anderson (1967).

³Unpublished reports available at the Forestry Sciences Laboratory, Rocky Mountain Forest and Range Experiment Station, Flagstaff, Arizona 86001.

Since the late 19th century, the Beaver Creek area has had various modifications by man, the earliest being introduction of domestic livestock. Most of the ponderosa pine area has been logged, which has changed the size and age class distribution from "natural" but has not caused major changes in the ecosystem. Protection from natural fire since the early 1900's has had a slow but cumulative effect.

Air temperature on the watershed ranges between -3° and 28° C (Schubert 1974). Average annual precipitation on the Beaver Creek watersheds ranges from 457 to 890 mm (Brown et al. 1974). Approximately 65% of the precipitation occurs in the seven winter months, usually in the form of snowfall, and about 35% in annual summer rains.

About one-third of the watershed area is covered by ponderosa pine (*Pinus ponderosa* Laws.) forests. Elevations in the pine type vary from about 2,070 to 2,440 m. The pine type is interspersed with Gambel oak (*Quercus gambelii* Nutt.) and, at lower altitudes, alligator juniper (*Juniperus deppeana* Steud.).

The pinyon-juniper forest type is made up of two subtypes which occur at elevations of 1,580 to 1,680 m for Utah juniper (*Juniperus osteosperma* Little) and 1,890 to 1,950 m for alligator juniper. Pinyon pine (*Pinus edulis* Engelm.) is interspersed in the two juniper types.

Multiresource Inventories

Multiresource inventory methodologies have been designed where the final objective is to interrelate various resource outputs which result from differing management treatments. Key indices or measurements of one resource must be linked to indices of the array of other resources.

Multiresource inventorying techniques were established using permanent recording stations, intermittent sampling schemes, and singular time-event and site-specific inventories.

Gaging stations have been designed to collect specific data on rate and volume of streamflows, minimum and peak flows, water temperatures, sedimentation, nutrient levels, etc. Pre- and post-treatment inventories and annual monitoring of species diversity, growth rates, and quality of shrubs, forbs, and grasses are ongoing. Research studies for identifying specific wildlife quantity and diversity have been completed. Pre- and posttreatment inventories of overstory vegetation, including measurements to determine growth rates, tree vigor, species composition, area volumes, nutrient makeup by tree section, mortality rate, decomposition rate, etc. are also ongoing. Measures of user's perception of the esthetics of the forest as related to changes in overstory or understory on site conditions have also been completed.

Data Base Management

Multiresource research directed at producing management guidelines or analytical methodologies for management results in large data requirements. The Beaver Creek research program involves pre- and posttreatment data collection on a wide array of resource impacts over long timeframes. These data are created from the above outlined multiresource inventories which have taken place on the Beaver Creek watersheds since 1958.

In major part, multiresource response data taken on the Beaver Creek watersheds have been utilized in development of management guidelines, single resource analytical models, and multiresource analytical models. Additional data are developed in other forested areas of the Southwest to corroborate findings at Beaver Creek and test analytical models developed from Beaver Creek data bases.

To provide adequate efficiency in tabulating, collating, retrieving, and using such extensive data, a data base management system (DBMS) is required. System 2000⁴, a DBMS developed by MRI, Inc. is utilized to manage the extensive data bases in the Beaver Creek research project. All major resources being studied in the project are, or will be, represented in System 2000.

⁴System 2000 is a trademark of Intel Corp. Mention of trade names does not imply endorsement or preferential treatment by the U.S. Department of Agriculture.

Although System 2000 is not fully satisfactory for the research mission, peripheral software allows the system to serve project needs. Its greatest weakness is that it does not allow interrelating various components and elements of the various trees of the data base. That is, access to components of a particular tree is hierarchical, top down.

MANAGEMENT IMPLICATIONS FROM MULTIRESOURCE RESEARCH

Implications of multiresource management have been derived for both ponderosa pine and pinyon-juniper forest types. They have been developed both for single resources and multiresources. Integrating management implications can fully characterize the resource tradeoffs that are to be expected from selecting one management alternative over another.

Single Resource Management Implications for Ponderosa Pine Forest Types

A meaningful way of relating management implications of research findings is to compare single resource responses to one or more differing management alternatives.

Twelve overstory management treatment alternatives in the ponderosa pine type are being studied at Beaver Creek. Of these, three will be used to illustrate expected impacts of treatments on various resources:

1. Clearcutting in strips: Watershed 9 treatment. Thirty-two percent of a watershed was clearcut in uniform strips 18 m wide with an uncut strip 36 m between strips.
2. Group selection thinning: Watershed 17 treatment. Seventy-five percent of the initial 11 m² of basal area was removed by thinning.
3. Clearcut: Watershed 12 treatment. Removal of all overstory, and slash windrowed.

In effect, these three treatments represent increasing removals of overstory from typical ponderosa pine watersheds. It is expected that the treatments would have differing impacts on the various forest resources. Following is an evaluation of those impacts.

Streamflow

Responses of winter streamflow for Watersheds 9, 17, and 12 are given in table 1. Post-treatment observations are related to predicted values from pre-treatment regression. For observations up to 6 years after treatments, Watershed 9 produced a mean increase of over 2.79 cm,

Table 1.--Summary of effects of treatments on winter streamflow from the pine watersheds.¹

Watershed and treatment	Untreated mean winter streamflow cm	Mean difference cm	Percent difference	Level of significance
Watershed 9 32% clearcut in uniform strips	17.02	2.79	16	0.05
Watershed 17 75% thin	19.38	4.27	22	0.05
Watershed 12 100% clearcut	15.34	5.16	34	0.01

¹Source: Brown et al. 1974.

Watershed 17 over 4.27 cm, and Watershed 12 over 5.16 cm. Thus overstory removal increases streamflow from managed stands.

Sediment

Over the period that the Beaver Creek watersheds have been monitored, sediment has been produced during peak winter and summer events. Expected annual sediment yield of normally stocked stands is between 0.04 and 0.09 metric tons per hectare.

Response of natural stands to treatment reveals considerable variability in sediment yield. Annual evaluations for 4 to 6 years after treatment indicate sediment yields from Watershed 9 vary from 0.02 to 2.9 tons/ha per year, Watershed 17 from 0.07 to 0.71 tons/ha per year, and Watershed 12 0.02 to 60.5 tons/ha per year. The 60.5 tons/ha per year resulted primarily from a 100-year event and is not considered a normal value.

It would appear from results to date that increased overstory removal produces increases in sediment.

Range

Total herbage production averages 221.8 kg/ha for untreated normally stocked pine stands. This consists of 138.9 kg of perennial grasses, 65.0 kg of forbs and half-shrubs, and 17.9 kg of shrubs.

Reduction of overstory invariably resulted in increases in the production of herbaceous plants, and shrub-type understory plants. These responses increased with increasing degrees of overstory removal (table 2). Watershed 17, after several posttreatment years, produced about 112 kg of additional herbage per hectare with one-half composed of grasses. Watershed 12 produced the most significant response with an annual average of 560 kg/ha increase.

Table 2.--Summary of effects of treatments on herbaceous and shrubby plant production¹ for the pine watersheds on Beaver Creek.

Watershed and treatment	Plant group	Production, untreated conditions kg/ha	Average increase over predicted kg/ha	Statistical significance of average change
Watershed 9 32% clearcut in uniform strips	Grasses	33.6	12.3	0.05
	Forbs, half-shrubs	29.1	44.8	0.01
Watershed 17 75% thin	Grasses	12.3	8.9	NS
	Forbs, half-shrubs	96.3	--	--
	Shrubs	50.4	--	--
Watershed 12 100% clearcut	Grasses	16.8	15.1	--
	Forbs, half-shrubs	224	265.4	0.01
	Shrubs	122	275.5	0.02
	Shrubs	22.4	23.5	NS

¹Source: Brown et al. 1974.

Wildlife

Most long-term study of wildlife on Beaver Creek has been directed at deer and elk populations. Evaluations in natural pine stands between 1959 and 1974 in Arizona revealed that deer and elk populations suffered a general decline. These findings were also supported by the intensive studies at Beaver Creek. Recent intensive study of other wildlife including birds, insects, carnivores, desert cottontail, Abert squirrel and forest rodents have identified relationships between habitat change and species diversity and numbers.

Wildlife habitats provide necessary environmental conditions for feeding, nesting, thermal cover, and protection from predators. All factors in combination define appropriate habitat for differing wildlife species.

Table 3 provides an evaluation of overstory removals on Watersheds 9, 17 and 12 and predicted deer populations. Evaluations are related to production of forage plants preferred by deer. On Watershed 9 only a small increase in preferred plants was noted, whereas Watershed 12 had a high increase in preferred plants. In table 4 it can be noted that deer and elk use as indexed by fecal droppings increases with available forage as indexed in table 3 by preferred forage species.

In general, opening the ponderosa pine canopy to enhance the understory forage supply improves deer and elk habitats (Neff 1980). It is still not possible, however, to predict the exact game response to any particular treatment.

Table 3.--Summary of effects of treatments on forage plants preferred by deer in the pine type on Beaver Creek.

Watershed and treatment	Deer forage production, untreated conditions	Average difference between actual and predicted production	Statistical significance of average change
	kg/ha	kg/ha	
Watershed 9 32% clearcut in uniform strips	17.9	19.0	0.01
Watershed 17 75% thin	33.6	--	--
Watershed 12 100% clearcut	77.3	135.5	0.05

¹Source: Brown et al. 1974.

Deriving direct association between wildlife habitat and densities is difficult. Most wildlife biologists and wildlife managers therefore avoid attempting to quantify cover requirements. Clear-cutting Watershed 12 (184 ha) was expected to cause a decline in deer use. In fact, however, deer use of this watershed is several times higher after treatment. The deer are apparently attracted by the abundant forage supply and browse while the slash windrows and Gambel oak sprouts provide sufficient cover and browse.

UNDERSTANDING THE IMPLICATIONS OF MULTIRESOURCE MANAGEMENT

Evaluations of the impacts of differing management alternatives on the varied multi-resources produced in the ponderosa pine forests include more than the examples of water, sediment, range, and wildlife referenced. Evaluations of other resources such as timber, esthetics, water quality, plant diversity, etc. are critical.

In addition to evaluating management alternatives in the ponderosa pine type, analyses have been conducted in the pinyon-juniper type on the Beaver Creek watersheds. These evaluations are providing equally useful information to land managers.

The interactions among forest resources and management treatments, and the natural processes which control these interactions, have been the basic thesis of research programs at Beaver Creek. Through study of the impacts of treatments on resources obtainable from southwestern forest types it is possible to characterize the processes involved in the increase or decrease of a particular resource and how that increase or decrease impacts other resources. Through study of these processes, guidelines for management of single resources and multiresources are developed. Further, predictive equations and process models

Table 4.--Summary of effects of treatments on deer and elk pellet group densities in the pine type on Beaver Creek.

Watershed and treatment	Pellet group density, untreated conditions	Average difference between actual and predicted densities	Evaluation
	Pellet group/ha per month		
Watershed 9 32% clearcut in uniform strips	Deer 0.20 Elk 0.49	0.08 -0.12	Not meaningful Not meaningful
Watershed 17 75% thin	Deer 0.32 Elk 0.40	0.77 1.46	Meaningful Meaningful
Watershed 12 100% clearcut	Deer 0.16 Elk 0.40	0.45 -0.08	Meaningful Not meaningful

¹Source: Brown et al. 1974.

are also developed, which can characterize the interrelationship of these resources.

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The Jornada Experimental Range Biosphere Reserve¹

Robert P. Gibbens²

Abstract.--The 78,106 ha Jornada Experimental Range is a research facility and operational cattle ranch in the northern Chihuahuan Desert. Continuous research programs since 1915 have provided much information on how to manage arid rangelands best. Current research, building on the past, is aimed at increasing products of direct benefit to man while preserving the integrity of basic ecosystems.

ADMINISTRATION

In 1912, lands designated as the Jornada Range Reserve were withdrawn from the Public Domain and placed under the jurisdiction of the U.S. Department of Agriculture. Originally administered by the Bureau of Plant Industry, the Range Reserve was transferred to the U.S. Forest Service in 1915. The Forest Service changed the name to the Jornada Experimental Range and carried out an active research program until 1954. At that time administration was transferred to the Agricultural Research Service which is now known as the Science and Education Administration-Agricultural Research (SEA-AR). The Experimental Range was designated a Biosphere Reserve under UNESCO's Man and the Biosphere Program in 1976.

Approximately one third of the experimental Range serves as a buffer zone for the U.S. Army's White Sands Missile Range. Public access to this portion of the Experimental Range is restricted but all research activities are permitted. Part of the mountainous portion of the Experimental Range is included in the San Andres Wildlife Refuge which is administered by the U.S. Fish and Wildlife Service.

Since its founding, the Experimental Range has functioned as an operating cattle ranch as well as a research facility. Grazing rights are leased to a private individual. Under present lease arrangements SEA-AR has complete control of livestock placed on the range and hires the personnel required for ranch operations.

¹Paper presented at the workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States. [Rio Rico, Ariz., April 20-24, 1981].

²Dr. Robert P. Gibbens, Range Scientist, U.S. Department of Agriculture, Science and Education Administration, Agricultural Research, Jornada Experimental Range, Las Cruces, N.M.

DESCRIPTION

Located 37 km northeast of Las Cruces in south-central New Mexico, the Experimental Range includes 78,106 ha of basin range topography representative of the northern Chihuahuan Desert. The major portion of the Experimental Range occurs on the Jornada de Muerte Plain where the relief is level to gently undulating. The plain is a closed basin with no eternal drainage, and water occasionally collects in scattered playas. From the plain, at an elevation of 1,260 m, the Experimental Range extends to the crest of the San Andres Mountains at an elevation of 2,833 m. Rocks in the mountains are derived from marine sediments deposited in the Paleozoic. A mosaic of soil types occurs, but in general coarse-textured soils are found near the foothills and silts and clays are concentrated in the lowest areas. Sandy soils predominate and both water and wind erosional processes contribute to continuous changes in micro-relief.

The climate is arid, with an average annual precipitation of 230 mm. Precipitation is concentrated in the months of July, August and September when 52% of the annual total occurs. Summer rainfall usually occurs as intense, convective thunderstorms which are of short duration and highly localized. In winter, low-intensity precipitation originates from frontal storms which cover wide areas. The average maximum temperature is highest in June (36 °C) and lowest in January (13 °C). The frost-free period averages 200 days but vegetation growth is usually limited to a shorter period when soil water is available. Relative humidities are usually low and evaporation from a free water surface averages 235 cm per year.

Early collections identified 524 species of higher plants. These are assembled into a wide variety of vegetation types. Shrub types are most abundant within the mountains and are dominated by honey mesquite (*Prosopis glandulosa*), creosote bush (*Larrea tridentata*), sotol (*Dasylirion*

wheeleri, ocotillo (*Fouquieria splendens*), and mesquit acacia (*Acacia constricta*). On the plains are found remnants of grasslands dominated by black grama (*Bouteloua eriopoda*), tobosa (*Hilaria mutica*), burrograss (*Scleropogon brevifolius*) and mesa dropseed (*Sporobolus flexuosus*).

Extensive vegetation changes have occurred since the turn of the century. The earliest vegetation records were made during a land survey conducted in 1858. These records, plus vegetation surveys made on the Jornada plain in 1915, 1928, and 1963 show that good grass cover had decreased from 90% of the area in 1858 to only 25% in 1963 (Buffington and Herbel 1965). Honey mesquite, creosote bush and tarbush (*Flourensia cernua*) have all encroached upon former grassland areas to the extent that no part of the plain is free of shrubs.

The wide diversity of habitats support about 400 species of mammals, birds, reptiles, and amphibians, plus numerous species of invertebrates. The actual number of animal species and specific or preferred habitats have not been well documented for some groups. All of the large native ungulates, pronghorn antelope (*Antilocapra americana*) mule deer (*Odocoileus hemionus*), and desert bighorn sheep (*Ovis canadensis mexicanus*), survive as viable populations although the bighorn population has been recently reduced by an outbreak of scabies. One introduced herbivore, the African gemsbok (*Oryx gazella*), is present in small numbers.

RESEARCH ACTIVITIES - PAST AND PRESENT

Much of the early research on the Experimental Range was concerned with livestock management, grazing effects, and the determination of utilization standards. Through the use of defoliation studies, permanent quadrat records, and permanent exclosures, a great deal of information was assembled on the autecology and synecology of the important plants and communities. From these studies evolved specific management strategies for the indigenous forage species (Paulsen and Ares 1962). The native fauna received less attention than vegetation although rodents and lagomorphs, which compete with livestock for forage, were the object of both life history studies and control efforts.

The ubiquitous increase in brush cover, which occurred in spite of good grazing management, led to intensive research on brush control methods (Herbel and Gould 1970) and on methods of seeding arid ranges after brush eradication (Abernathy and Herbel 1973). Diets and activities of different breeds of livestock were examined to determine their adaptability to arid rangelands (Herbel and Nelson 1966). The limiting role of soil water was recognized and examined in relation to different soil types and plant responses (Herbel and Gile 1973).

Both the grassland and desert biomes of the International Biological Program conducted research on the Experimental Range. Under these programs primary productivity and the interrelationships of consumers and decomposers were investigated. Much information was acquired on the structure and function of the black grama grassland ecosystem (Pieper et al. 1972).

The current basic and applied research on the Experimental Range are aimed at fulfilling two broad objectives: (1) The development of range improvement practices for increasing productivity of rangelands and (2) The development of grazing management systems which convert range forage more efficiently to animal products and are consistent with improvement, conservation, and multiple use of range ecosystems. A wide variety of projects, many in cooperation with scientists from New Mexico State University and other government agencies, are being conducted by the resident research staff.³

Studies are being conducted to find means of better utilizing the limited supplies of water. Rainfall inputs, interception of rainfall by plant cover, infiltration rates and soil water levels are being studied following brush control by chemical and mechanical methods. Runoff and sediment yield from a watershed dominated by creosote bush are being measured so that the effect of future brush control efforts can be determined. The effects of water ponding on barren rangeland sites and on sites with native vegetation are being determined. Retention dams and waterspreading systems are being examined as a means of controlling and utilizing wild water runoffs resulting from intense thunderstorms.

The photosynthetic efficiency of major forage species, both native and introduced, relative to soil water, irradiation and temperature are being determined. The development of a technique for in situ measurement of root respiration has allowed the evaluation of physiological-based plant adaptations to arid environments in terms of whole-plant carbon uptake (photosynthesis) and carbon loss (respiration). Predictive models of plant responses are the objective of phenological measurements of grass, forb and shrub species accompanied by continuous monitoring of precipitation, soil and air temperatures, wind velocities, total and net radiation and soil water.

Since many productive range sites are now dominated by brush species, methods of brush control and subsequent land management have a high priority. The future use of 2,4,5-T, long employed in mesquite control, is in doubt and the effectiveness of alternative herbicides is being

³The current research staff includes Drs. Carlton H. Herbel, Research Leader; John M. Tromble, Hydrology; Robert P. Gibbens, Range Ecology; William B. Sisson, Plant Physiology; and Dean M. Anderson, Animal Nutrition.

investigated. Tebuthiuron shows promise of being able to control most brush species with minimum deleterious effects if applied at proper rates. Nursery and field-scale plantings to evaluate introduced and improved forage species are being made so that the forage base may be improved following brush control.

A major study now nearing conclusion has involved the investigation of the effects of brush control on a large area of mesquite dune-lands. A 3,630 ha study site was treated with 2,4,5-T and a similar-sized area reserved as a control. Studies have been conducted on the sprayed and control areas to determine grass and forb productivity; populations of birds, rodents, insects, and soil microorganisms; time span of herbicide degradation; cattle diets and activities. The information collected will be useful in assessing the impact of large-scale range improvement programs.

Livestock and their management are objects of study in several current projects. The Experimental Range is one of a nation-wide network of sites where the performance of Angus-Hereford and Brahma-Hereford crosses will be evaluated under different climatic regimes. The use of sewage sludge as a supplemental feed is under investigation. Heat synchronization and artificial insemination are being employed to improve the timing of calving. Early weaning and drylot confinement are being evaluated as possible means of improving conception rates. Also, the Jornada herds are being used to determine the effectiveness of insecticide-impregnated ear tags for horn fly control.

Short duration grazing is being compared to continuous grazing on tobosa grassland, including the influence of the systems upon cattle performance, diets, and activities. Field tests of a transponder implanted under the skin of livestock and containing an identification number and a temperature sensor are being conducted. The transponder, used in conjunction with an interrogation unit, an electronic scale, and a recording unit, permits the acquisition of unrestrained cattle weights. Continuous automatic weighing of livestock may have potential in determining herd health and evaluating performance.

The Experimental Range has been selected by the National Aeronautics and Space Administration as a primary study site for the evaluation of remote sensing in desertification monitoring. This program is being carried out in close cooperation with Mexico where additional test sites are being studied.

Past and present research programs have maintained continuous records of precipitation, vegetation and stocking rates. The infrequency of occurrence of extreme wet and extreme dry periods in an arid environment make long-term records and studies a necessity. Life history strategies of plants and animals must be examined over the full spectrum of climatic oscillations if the available resources are to be wisely exploited for man's use. Since the current research program is mission oriented and has a finite budget it is somewhat restricted in scope. This does not detract from the fact that, with a long-term data base upon which to build, the Jornada Experimental Range offers unparalleled opportunity to study man's interactions with grazing lands in an arid environment.

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Organ Pipe Cactus National Monument: A Biosphere Reserve in the Sonoran Desert, Southwestern United States¹

R. Roy Johnson²

Abstract.--Organ Pipe Cactus National Monument on the Mexican border of Arizona is an outstanding example of the Sonoran Desert in the United States. The Sonoran Desert is the richest of the North American deserts in vegetation series and associations as well as plant and animal species diversity. The Monument serves as a pristine control area against which to measure the impact of grazing, irrigation, urbanization, and other technological activities in the Sonoran Desert.

INTRODUCTION

Organ Pipe Cactus National Monument consists of approximately 335,000 acres (135,600 hectares, 525 square miles) situated along the Arizona-Mexico border in the north-central section of the Sonoran Desert. It is approximately 140 miles (225 kilometers) from Phoenix and Tucson, the two largest cities in Arizona, which account for much of the Monument's visitors, and 15 miles (24 kilometers) south of the town of Ajo, with a population of approximately 8,000. The Monument is bounded on the west and north by the Cabeza Prieta Game Range, a refuge for the endangered Sonoran pronghorn and desert bighorn sheep. The Papago Indian Reservation occurs along its entire eastern boundary and to the south is the state of Sonora, Mexico. Arizona Highway 85 bisects the Monument, north and south, and at the international border meets Mexico National Highway 2, a popular route to the Mexican fishing village and tourist resort of Puerto Penasco (Rocky Point) as well as the mainland of Mexico and Baja California.

ORGAN PIPE AS A NATIONAL MONUMENT

National Park Service lands in the natural area category have been established by Congress to "promote and regulate the use of the Federal areas known as national parks, monuments, and reservations"... "which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

¹Paper presented on the Wildlife and Range Research Needs in Northern Mexico and Southwestern United States, Rio Rico, Arizona, April 20-24, 1981.

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Under these guidelines Organ Pipe Cactus National Monument was established on April 13, 1937, by Presidential proclamation to protect, preserve, and interpret the natural scenic and historical resources of the area for the benefit and appreciation of the people.

In conformance with the Wilderness Act (P.L. 88-577) of 1964, approximately 313,000 acres (126,700 hectares) of Organ Pipe Cactus National Monument were set aside to "assure that an increasing population, accompanied by expanding settlement and growing mechanization, does not occupy and modify all areas within the United States and its possessions, leaving no lands designated"... and to be "administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, and so to provide the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness..."

ORGAN PIPE AS A "NATURAL AREA"

The Sonoran Desert may be considered a distinct central component of the great North American desert which extends from eastern Oregon to Pueblo, Mexico. The boundaries of the Sonoran Desert are defined on the basis of vegetation. The combination of physiographic and climatic variations have resulted in making this one of the more ecologically diverse of the world's desert resources. The Monument contains a greater variety of geological features, desert vegetation, fauna, and other natural attributes than most other Sonoran Desert areas of comparable size in the United States.

The Sonoran Desert is the richest of North American deserts in vegetation series and associations as well as plant and animal species. This is especially true when wetlands are included. This desert is well named, for it is the only area

in the United States that has a direct connection with the tropical Mexican (Sinaloan) thornscrub (Johnson et al. 1980). The Sonoran Desert is classified by Brown et al. (1979) as Tropical-Subtropical Desertlands in contrast to the other North American deserts which are classified as Warm Temperate Desertland or Cold Temperate Desertland. It is included by Bailey (1978) in the American Desert Province.

Although many of the plant species which typify the Sinaloan thornscrub reach their northern limits south of the United States-Mexican boundary, a large percentage of the genera extend north into the United States. This is particularly true for woody legumes such as acacias (*Acacia* spp.), mesquites (*Prosopis* spp.), paloverdes (*Cercidium* spp.), and mimosas (*Mimosa* spp.). The number of species of large cacti, e.g., *Cereus* spp., also diminishes as one progresses northward.

Despite its relatively low variation in elevation, 1000 to 4800 feet (305 to 1460 meters), and rainfall, 4 to 15 inches (100 to 380 millimeters), Organ Pipe Cactus National Monument boasts approximately 500 species of flowering plants of which 29 are cacti, plus several additional varieties (Bowers 1980). Several additional plant species, including the senita or "old man cactus" (*Cereus schottii*) occur nowhere else in the United States. A recent study of the "Vegetation of Organ Pipe Cactus National Monument" (Warren et al. 1980) listed three upland formations: Forest and Woodland communities, Scrubland, and Desertland (after Brown et al. 1980); and one wetland formation, Marshland. In addition, a few small patches of another wetland formation, Riparian Scrub, occurs around Quitobaquito, Aquajita Spring, Williams Spring and several other smaller seeps or spring areas in the Quitobaquito Hills. The main vegetation there includes mesquite (*Prosopis* spp.), *Pluchea* spp., and seepwillow (*Baccharis glutinosa*). Warren et al. (1980) have listed approximately 30 plant associations for the Monument.

This great variety of habitats supports a correspondingly diverse desert fauna. Few studies have been conducted on the vertebrates of this remote area since Huey's earlier publication (Huey 1942). More than 43 species of mammals are known, as well as approximately 225 species of birds of which about 40 are permanent residents (Wilt 1976). The pond at Quitobaquito with its riparian and marshy growth provides diverse habitats for migratory and wintering waterbirds as well as transient and resident land birds. The Monument supports an unusually rich herpetofauna (Huey 1942) that includes 5 toads, 3 turtles, 15 lizards, and almost 30 snakes, including the Gila Monster (*Heloderma suspectum*); and 7 species of poisonous snakes, including the Arizona coral snake (*Micruroides euryxanthus*), and 6 rattlesnakes (*Crotalus* spp.). Although the insects, centipedes, millipedes, tarantulas, and other invertebrates are poorly known, some investigations now in progress have resulted in the discovery of species new to science.

The variation in topographic relief at the Monument results largely from two predominantly igneous mountain systems; the Ajo Mountains and the Puerto Blanco-Bates mountain system. The ridge of the Ajo Mountains forms most of the 25-mile long eastern boundary with the Papago Indian Reservation. In addition to the previously mentioned permanent springs, Dripping Springs occurs in the Puerto Blanco range and several smaller, usually intermittent, springs are scattered throughout the Monument. Infrequent tinajas (rocky depressions) catch runoff water in some areas and are used as watering sites by large mammals. Artificial water sources are located at scattered localities, usually in the form of hand dug wells with or without windmills. These remnants of the old cattle grazing operations are currently being examined for the possibility of elimination in keeping with the philosophy of the perpetuation of natural ecosystems in National Park Service natural areas.

Studies now being conducted by the National Park Service's Cooperative National Park Resources Studies Unit at the University of Arizona and the Organ Pipe Cactus National Monument staff are determining the dependency of wildlife on natural as well as artificial water sources. It is especially important to determine if any of the developed water sources are critical to the survival of any endangered or threatened species of native wildlife. The project will involve systematically monitoring surface water availability and will dovetail with other work presently underway by the State of Arizona and federal agencies working on the Sonoran Pronghorn Recovery Team effort and white-tailed deer (*Odocoileus virginianus couesi*) study. The Fauna Survey/Inventory is also a necessary prerequisite to comply with the Endangered Species Act. Several endangered species are known to be present, i.e., Sonoran pronghorn (*Antilocapra americana sonoriensis*), peregrine falcon (*Falco peregrinus*), desert pupfish (*Cyprinodon macularius*), and other possible additions, i.e., Mexican wolf (*Canis lupus baileyi*).

Information gathered by our studies will be used in presenting alternatives to management regarding the retention or elimination of these artificial water sources.

Based on this knowledge, decisions will be made to determine whether to continue to maintain the waters presently maintained and/or develop others. Decisions are needed, too, on tinaja maintenance. Should managers actively manage these waters, for example, by cleaning out these natural rock catchments periodically to remove the sand and rock debris, thereby introducing an artificial element or should they be permitted to fill in, thereby reducing their storage capacity? Should the capacity of selected tinajas be expanded artificially? How many sources of historic water were eliminated by man's activities, such as grazing, and where? These and other questions relating to the wildlife-water picture require solutions (USDI-Peters 1981).

ORGAN PIPE AS A BIOSPHERE RESERVE

The concept of MAB-8 Biosphere Reserves was formalized by the International Coordination Council at its first session (in November 1977) for the Conservation of Natural Areas and the Genetic Material They Contain. In September, 1973, the Expert Panel on Project 8 formalized the objectives for the international network of biosphere reserves as a United Nations Educational Scientific and Cultural Organization project as follows (Risser and Cornelison 1979):

1. To conserve, for present and future human use, the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends.
2. To provide areas for ecological and environmental research including, particularly, baseline studies, both within and adjacent to these reserves, such research to be consistent with objective (1) above.
3. To provide facilities for education and training.

The critical criteria for selection of these Biosphere Reserves are:

1. Representativeness. This criterion is primary for selection. A reserve should represent as many of the characteristic features of the particular biome as possible, so that information relating to the nature and dynamics of the reserve area can be extrapolated to similar areas throughout a biogeographical region.
2. Diversity. Representative Biosphere Reserves should contain the maximum representation of ecosystems, communities and organisms characteristic of the biome. Ecosystem level diversity has the highest priority, so that it is primarily concerned with the degree to which the range of habitats characteristic of the biome is present in any one area.
3. Naturalness. Selection of representative samples of biomes in their natural state necessitates a high priority being placed on naturalness, the least modified areas being the most appropriate.
4. Effectiveness of an area as a conservation unit. This criterion involves a number of factors such as size, shape, and location with respect to natural protective barriers. Optimum size depends largely on the type of system and the requirements of the species involved. The ideal area is one which is sufficiently large to be self-regulating, through the inclusion of all the interacting components. Also, there should be adequate buffer zone compatibility ensuring that the land use of surrounding areas is compatible with the objectives of the reserve.

Organ Pipe Cactus National Monument meets all four of these criteria admirably. Its situation both at a central location in the Sonoran Desert and centrality in regards to the composite "Great North American Desert" make it an exceptionally representative area. We have previously discussed the great diversity of which Organ Pipe Cactus

National Monument is illustrative. This pertains especially to the vascular flora and vertebrate fauna. The only factor which in the past has had a noticeable affect on the naturalness of the area was grazing. With the recent removal of all livestock from the Monument, grazing impacts have been reduced. Follow-up studies have been planned to measure the rate of the re-establishment of natural conditions. The combination of the large size and remoteness of the Monument greatly enhances its effectiveness as a conservation unit. It is surrounded to the north, east, and west by equally remote areas in which grazing is the primary disturbance. The major threat to the Monument's natural ecosystems is the pumping of groundwater for irrigation in the Sonoita River Valley in adjacent Mexico and the possible consequences to the underground water table in the Monument.

WILDLIFE MANAGEMENT AND GRAZING

In contrast to many of the other areas being discussed in this symposium Organ Pipe Cactus National Monument is managed for the perpetuation of natural ecosystems and the processes associated with these ecosystems. Thus, native wildlife are managed while grazing is excluded. The Monument is an ideal area for this type of research with wildlife and grazing for these reasons:

1. It is large enough to contain a variety of habitats.
2. It is one of the few areas in this region where grazing is excluded.
3. Due to the remoteness of the region a minimum of human related factors have to be dealt with; some only during the last decade. Follow-up studies on the recovery of wildlife and their habitats are now being conducted on the Monument.
4. Livestock have been totally removed from the area.

Therefore Organ Pipe Cactus National Monument serves as an excellent area for the evaluation of various types of grazing management and their impacts on these desert ecosystems. Thus, by serving as a control against which to measure grazing and wildlife management on nearby areas, this component of the National Park Service system becomes a valuable unit in the Biosphere Reserve complex.

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Evaluation of Wildlife Resources in the Higher Elevations of the Sonora River Basin¹

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Abstract.--This work indicates the need for research to develop multiple-use technologies for the conservation and management of natural resources; it also points out the need to complete diagnostic studies on regional problems.

INTRODUCTION

Wildlife is a resource closely linked to vegetation; both are essential parts of the ecosystem, closely related with its other components.

According to the General Administration of Wildlife, 3,500 hunting permits are issued each year in Sonora; this is a minimal figure compared to the number of illegal hunters in the state. The wildlife resource is declining due to irrational utilization, and to alterations of the ecosystem due to human activities.

We lack sufficient information about the current status of many species, so we are unable to determine their populations. We must determine the current status and conditions of the wild animal populations in order to establish periodic evaluations which will allow us to observe the variations that affect them.

BACKGROUND

In 1936, President Lázaro Cardenas declared 21,494 ha of land within Sierra Los Ajos, Buenos Aires and La Purica, a National Forest Reserve under the jurisdiction of the Department of Forestry, Fish and Game, in order to protect the basins of the Yaqui and Sonora rivers.

The National Institute of Forestry Research (INIF) began some activities in the higher elevations of the Sonora River basin, specifically in the village of Cananea, in 1974.

On August 22, 1979, the Director General of INIF formally established "Cananea" as a branch of

the Northern Forestry Research Center with the purpose of developing research which would facilitate the multiple utilization of natural resources.

In December 1978, Mexican authorities met in Fort Collins, Colorado with personnel of the Rocky Mountain Forest and Range Experiment Station regarding the Beaver Creek Project to discuss the possibilities for scientific and technical exchanges and for the involvement of Mexican investigators in cooperative studies on multiple use of natural resources.

Finally, on February 21, 1980, a binational agreement was reached for technical-scientific cooperation, signed by forestry experts from both countries, with the following objectives:
--To conduct joint research on multiple-use management of resources.
--To develop and to improve methodologies for multiple inventory of resources.
--Education, training, and technology transfer.

CHARACTERIZATION OF THE AREA

a) Location

The Sonora river basin is located approximately between 29° and 31° latitude North, and 110°45' and 111° longitude West of the Greenwich meridian.

The basin falls within 10 townships: Aconchi, Arizpe, Bacoachi, Banamichi, Bavicora, Cananea, Hermosillo, Huepac, San Felipe, and Ures, with a total area of 2,911,000 ha.

Because it is very extensive, the National Institute for Forestry Research has planned to study the higher elevations of the basin during the first stage, with the following boundaries:

On the east, Los Ajos, Buenos Aires, and La Purica ranges, with maximum elevations of 2620 meters above sea level. The northern boundaries correspond to the coordinates of the city of Cananea, equivalent to 31° latitude North.

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The San Miguel river forms the western boundary; the south boundary corresponds to 30°35' latitude North, crossing the towns of Bacanuchi and Bacoachi. This region is 2095 KM², equal to 10% of the total area.

b) Climate

There are three types of climate within the basin, depending on the elevation.

In the areas with pine vegetation, the climate is sub-humid temperate, with summer rains, a yearly mean temperature of 13°-18°C, and a frost-free period which varies from 150-210 days per year. Precipitation is 550 to 750 mm from July to September, and some snow in winter.

In the oak forests the climate is dryer, arid temperate, with a yearly mean temperature of 13° to 18°C, and precipitation from 350 to 550 mm per year.

In the grassland and shrub zones the climate is arid semi-warm; the yearly mean temperature varies from 18° to 20° with a temperature of 8° to 10°C in the coldest months, and a frost-free period of 200-240 days per year; rainfall is 350-400 mm, with summer rains as a rule, and some winter precipitation in the form of snow.

c) Geology

Formations of volcanic Cenozoic and Superior Classic Cenozoic predominate in the mountain ridges and in the hills. The rocks are intrusive and extrusive igneous of the rhyolite, basalt, conglomerate, mica schist, lava, ashes, volcanic glass and limestone groups, the latter being of sedimentary origins.

In the middle and lower areas there are formations from the Pleistocene and from Superior and Recent Paleozoic.

d) Soils

The soils in the basin are varied due to the variations in their origin and in the topography, but they can be grouped according to their location within the basin.

Those in the higher elevations are formed "in situ", derived from igneous rocks, basalts and schists with abundant mica; their color is grayish or darker gray, depth shallow to medium (10-50 cm), sandy texture or clayey, with gravel and stones, good drainage and rich in organic matter in the surface layer.

In the middle part of the basin the soils are light brown; texture varies from sandy-clayey topsoil to clayey-sandy; pH neutral to slightly alkaline, shallow, immature, with 40-50% gravel, stone and rocky protrusions.

In the grassland areas, soils originate from granitic, metamorphic and sedimentary rocks; they

are colluvial or alluvial according to their "in situ" formation; depth varies from shallow to medium, color from dark brown to dark gray, texture sandy to sandy muddy; there are stones and gravel on and beneath the surface.

In the low areas there are salt accumulations that allow the hardening of the plowable layer; their drainage is deficient.

e) Hydrology

There are many permanent and temporary streams that flow from the mountains of Cananea, Los Ajos and Buenos Aires, and constitute the origin of the Sonora river; many towns such as Bacoachi, Arizpe, Bavicora, Ures, and Hermosillo utilize this river.

Among the important tributaries of this river there are some of lesser importance such as the Baconuchi, which flows from the Cananea mountains and whose confluence is in Arizpe, and the San Miguel river which merges at the top of Ures.

Down river, in the city of Hermosillo, the Abelardo L. Rodriguez Dam provides water to the population.

f) Vegetation

In spite of the disturbance the vegetation has experienced, especially during this century with mining activities, there are five types of vegetation:

Pine forests.--Located on the peaks and high slopes of the ridges from 1800 to 2500 meters above sea level. Some species are Pinus chihuahua huana, P. engelmannii, P. ayacahuite, var. brachyptera, P. reflexa and P. arizonica. Abies concolor and Pseudotsuga aff. flahaulti are found in the glens. Some of the deciduous species in this forest are: Quercus spp., Juglans sp., Fraxinus sp., and Populus tremuloides.

Pine-Oak Forests.--Distributed altitudinally between 1500-1800 meters above sea level. Some species are: Pinus chihuahuana, P. cembroides, Juniperus deppeana, J. monosperma, Quercus emory, Q. arizonica, Q. oblongifolia, Q. reticulata, and Q. chihuahuensis.

Gallery forests.--Found along the margins of running waters. Some of the trees are: Platanus wrightii, Alnus oblongifolia, Acer brachypterum, Fraxinus sp., Populus sp., Juniperus flaccida, and Quercus sp.

Grassland.--Located primarily on flat land, with some hills and small glens; east boundaries are the Los Ajos, Buenos Aires and La Purica mountains; west boundary is the Cananea mountain extending from the town of that name to where the Sonora river begins its rapid descent. Characterized by its diverse flora, this type includes species of the genera Bouteloua, Hilaria, Aristida, Muhlenbergia, Lycurus, Eragrostis and Bromus, plus various shrubby forage species.

Oak Forest.--This is a type of primary veg-

etation suitable for the transition zone and, possibly, because of the extensive harvesting of conifers, oaks cover a large part of the mountains, especially in the lower parts, where the most common are Quercus emory and Q. oblongifolia.

g) Wildlife

The wooded zone, especially the one corresponding to the reserve that includes the Los Ajos, Buenos Aires and La Purica mountains, gives shelter to a varied wildlife.

Among the species are: mule deer, javelina, coyote, fox, mountain lion, squirrel, rabbit, hare, wild turkey, black bear, white-tailed deer, golden eagle, armadillo and many others.

Through information gathered about the region, we noted that some species have disappeared (otter, beaver), others are threatened (black bear), and others are in danger of total extinction (wolf, grizzly bear); also currently there is great danger for others such as the mule deer, white-tailed deer, javelina, mountain lion, bobcat, wild turkey and coyote.

In the study area there are two private hunting ranches known as San Jose de la Cuesta and La Volanta; various species are managed there, including deer, elk, antelope, bison, and bighorn sheep.

OBJECTIVES

Our basic objective is to conduct research projects to develop or adapt technologies which will facilitate the management and conservation of natural resources in the higher elevations of the Sonora river basin. Special attention will be given to the wildlife, water, conservation, range, and forestry uses.

GOALS

So that this project can reach the objectives mentioned previously, activities will be divided according to common problems, and various goals have been established for the advancement of research.

The following objectives are to be met during the period between January 1 and December 31, 1981:

- Consolidate "Cananea" by the establishment of offices and laboratories in "Mesa del Rayo", and hire personnel to initiate and conduct a permanent training program.
- Conclude the diagnostic studies to define clearly the regional problem, so that this information will be useful as a reference framework for further research.
- Evaluate the effects of cattle ranching, mining, and forestry activities actually conducted in the area of study.
- Evaluate the current methods used to protect the sub-basin.
- Initiate work which will allow the measurement of erosion.

--Evaluate the salinization levels of the waters and determine clearly the source of contamination.

--Conclude the wildlife inventory and initiate a population census.

--Initiate studies on the recovery of forest areas and natural grasslands.

--Evaluate the management and commercialization of regional forestry products.

--Prepare a mosaic on current and potential soil utilization for the region under study.

--Finally, develop socioeconomic studies which will define the feasibility of utilizing research results, or which will show how they can be modified to become viable.

WORK PLAN

To evaluate wildlife resources we must adapt the sampling techniques to the type of vegetation and to the topography of the area studied. This will not only give us more accurate knowledge about the number of species and their population densities, but we will also be able to note fluctuations which may occur within that period and space. In other words, we will be able to understand the population dynamics of the species as well as their inter- and intraspecific relationships. This information, together with the information about basic biological aspects of each species, will enable us to manage this area; the inventories conducted periodically will be used only to verify the results obtained.

To fulfill the aforementioned, it would be convenient to initially divide the sampling area into plots no larger than 15 ha nor less than 5 ha; the selection of the plots to be sampled would be totally at random. The valid minimum for sampling is known to be 10%, but because of the characteristics of the study and the field, we will attempt to sample more than 50% of the total area.

The data gathered in this study will be entered in established formats; some of the more important information to be entered is the following: Species, common name, location, type of vegetation, time of sampling, number of animals observed, type of sampling (maximum visual reach, direct observation, tracks, droppings, sounds).

Based on the data collected, we will have information about spatial distribution, relative density, population mean and standard error, and percentage of females, males, young.

GENERAL CONSIDERATIONS

Natural resources (land, forests, and wildlife) deserve attention and should be rationally utilized within the area. Much of the Sonora river basin is overgrazed, deforested, or eroded as a result of inadequate management of the natural resources of the region.

Therefore, only a combined program integrating various components to form one unit will accomplish the adequate management of natural resources, thus increasing the lumber, water, forage, and wildlife

production in a permanent and uniform manner.

Concerning the protection and conservation of natural resources, confusion has led some people to compare conservation with low consumption levels and to totally reject technology. The conservation goals will be reached only with perfect technology, and only adequate attention to the ecology and to the values of conservation will attain the goals of economic development without creating serious and undesirable disturbances in the environment.

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245 The Santa Rita Experimental Range¹

Kieth E. Severson and Alvin L. Medina²

Abstract.--The Santa Rita Experimental Range was established in 1903 for research on arid land environments. Research emphasis supports range livestock production on semidesert grasslands. This paper describes the Range, the background of information currently available, future research direction, and possibilities for cooperative studies.

INTRODUCTION

The Santa Rita Experimental Range was established in 1903 for research on arid land environments, specifically semidesert grasslands, that would benefit the range livestock industry. It is administered by the USDA Forest Service. This 20,500 ha outdoor laboratory (fig. 1) is 48 km south of Tucson, Arizona, USA, and 72 km north of Nogales, Sonora, Mexico, on a broad bajada that slopes northwestward from the Santa Rita Mountains to the Santa Cruz river. Elevation varies from 850 m at the northwest corner to 1,500 m along the foothills of the Santa Rita mountains.

Physical Features

Soils are composed of pliestocene alluvium from mixed rock sources that form the gently sloping bajada. About half of the soils are classified as Aridisols, one-quarter as Mollisols, one fifth as Entisols, and the remainder as gravelly alluvium or rock. Paleocene granitic rocks and Upper Cretaceous quartz monozonite and granodiorite occur near the mountains. Small areas underlain by limestone are found in the northeastern portion of the Range.

Climate

Average yearly rainfall ranges from about 250 mm at 880 m to almost 500 mm at 1,300 m. Approximately 60% of the annual precipitation falls from convectional storms between July 1 and September 30. Rainfall during April, May, and June is generally so deficient that it rarely produces growth in plants (Martin and Reynolds 1973). Average daily temperatures exceed 32° C in June and July. Daily minimum temperatures average below 4° C in December, January, and February. The frost-free period is about 240 days at upper elevations of the Range, but growth of herbaceous plants usually is limited by lack of moisture to about 56 days (Martin 1966).

Vegetation

Vegetation has changed since the Range was established (fig. 2). *Prosopis juliflora* now dominates between 20,000 and 30,000 acres (8,000-12,000 ha) that were essentially shrub-free grasslands 80 years ago. *Eragrostis lehmanniana*, introduced from South Africa, has spread and formed pure stands over large areas in the southern and southeastern parts of the Range.

Perennial vegetation over most of the Range is dominated by invasion stands of *Opuntia fulgida*, *O. spinosior*, *O. versicolor*, and *O. engelmannii*. *Prosopis*, *Haplopappus tenuisectus*, and *Opuntia* spp. reach their highest densities between 3,200 and 3,600 feet (970 to 1,100 m) elevation; *Prosopis* and *O. engelmannii* are major species even above 4,000 feet (1,200 m). Other shrubs, including *Acacia greggii*, *A. angustissima*, *Mimosa biuncifera*, *M. dysocarpa*, and *Calliandra eriophylla* make up only 21% of the shrub cover below 3,200 feet (970 m) but comprise 65% of the shrub cover above 4,000 feet (1,200 m). *Fouquieria splendens* occurs at all elevations, mainly on rocky sites (Martin 1966, Martin and Reynolds 1973).

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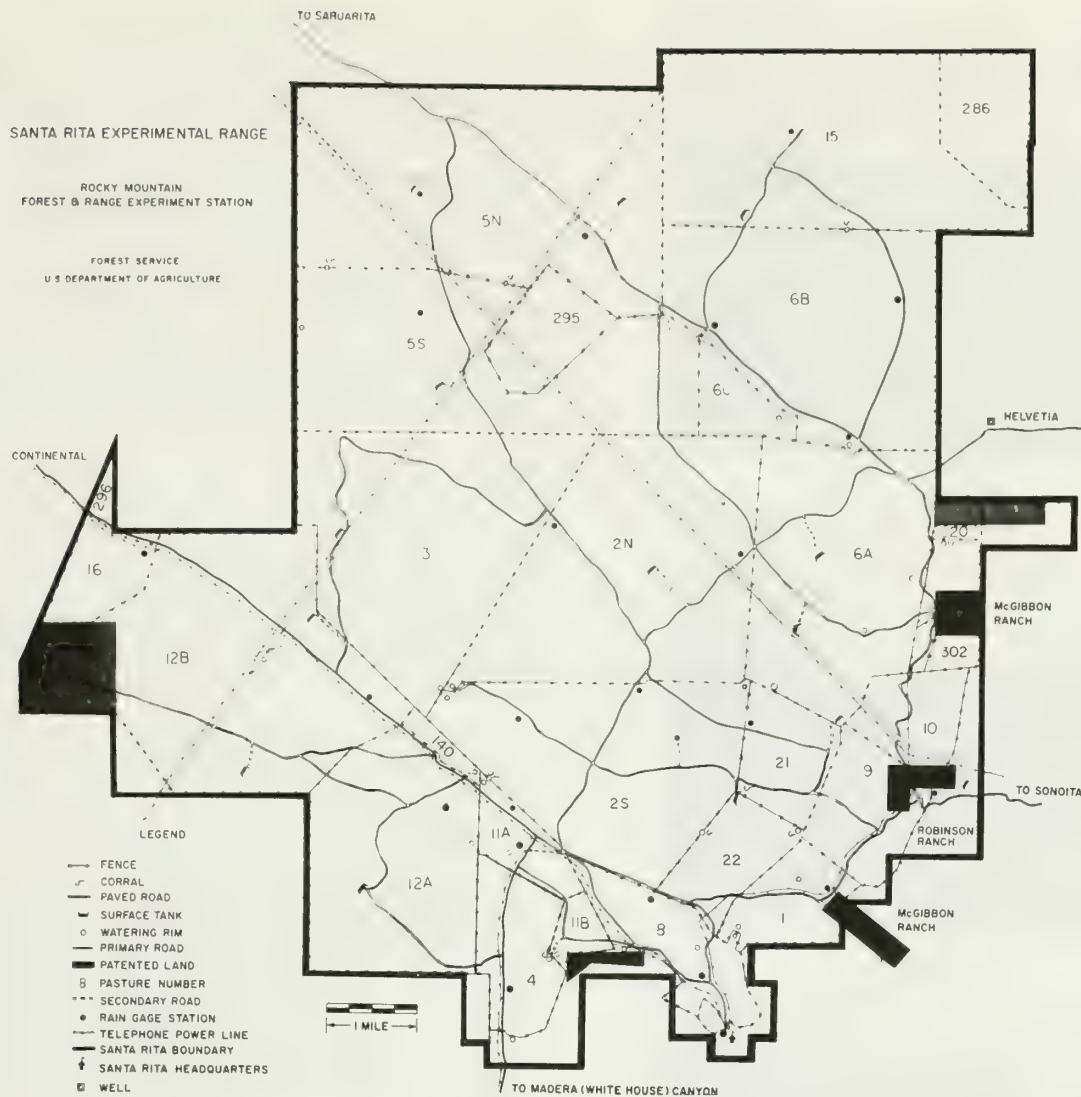


Figure 1.--The Santa Rita Experimental Range, Arizona
(Martin 1966).

The abundance and composition of perennial grasses varies with rainfall and elevation. *Aristida glabrata* and *Bouteloua rothrockii* are major species at the middle and lower elevations, but are minor species above 4,000 feet (1,200 m). *Muhlenbergia porteri* makes up a greater part of the grass stand at lower than at middle elevations, and is scarce at upper elevations. Others, including *Bouteloua eriopoda*, *B. filiformis*, *B. chondrosioides*, and *B. hirsuta* make up over 60% of the stand at upper and middle elevations. Other grasses, *Aristida hamulosa*, *A. ternipes*, and *Trichachne californica*, are common throughout the Range (Martin 1966, Martin and Reynolds 1973).

The major vegetation-site complexes on the Santa Rita are characterized in Table 1. The *Prosopis-Opuntia-Haplopappus* complex is by far the largest, although others occupy areas extensive enough for study and observation.

Wildlife

Twenty-three species of mammals, 23 birds, and 10 reptiles occur commonly on the Range. Relatively few have been intensively studied.

BACKGROUND INFORMATION

Past research is well documented in a variety of publications on plant and animal ecology as well as on livestock grazing. Available records include: (1) longtime records of stocking, forage production, vegetation cover, and utilization on 26 pastures; (2) monthly precipitation from 28 stations, some dating back to 1922; (3) numerous permanently marked transects and plots; (4) series of photographs from over 300 permanently marked photo stations; (5) more than 300 study areas, including exclosures, where the results of protection or other treatments may be observed; (6) soil, wildlife, and geological surveys; and (7) aerial photographs taken in 1936, 1956, 1966, and 1978.

In addition to Forest Service scientists, the Santa Rita Range has also been used by cooperating researchers from State and other Federal agencies, visiting scientists, and graduate students. The University of Arizona's library, herbarium, laboratories, and faculty provide readily available support for research. Conversely, the Santa Rita has been an easily accessible field laboratory for the University.

Extensive range research has been done in such areas as: (1) grazing systems; (2) shrub control; (3) grass-shrub ecology; (4) revegetation techniques; and (5) vegetation/utilization measurement techniques.

Wildlife research has centered on species that influence livestock range use and production, such as the lagomorphs Lepus alleni and L. californicus and several rodent species. Some work has also been done on other economically important species sought by sport hunters, such as Odocoileus hemionus, O. virginianus, Tayassu tajacu, and Lophortyx gambelii, or for their fur, as Canis latrans. Only limited work has been done on non-game wildlife.

At present, the research program on the Santa Rita Experimental Range involves seven research groups and numerous individuals working together and independently on more than 30 studies.

Future emphasis of Forest Service research will center on wildlife-livestock relationships. Plans are underway to study interactive effects of livestock behavior and grazing on wildlife and their use of habitat. One particular study will deal with interspecific/interactive relationships of cattle and Odocoileus hemionus crookii, as influenced by various range treatments. Treatments may include different cattle stocking intensities, different grazing systems, and range habitat manipulations (burning, shrub control, water development). Methods of manipulating livestock grazing to enhance certain components of wildlife habitat, especially cover requirements will be emphasized. In addition, new techniques of interpreting behavioral interactions will be developed using video tapes for visual analysis, and computer software to analyze telemetry data.



1903



1942



1981

Figure 2.--This series of photographs, taken in 1903, 1942, and 1981, documents vegetation changes on a portion of the Santa Rita Experimental Range. The major change between 1903 and 1942 was the increase in Prosopis juliflora; between 1942 and 1981 it was the replacement of the native grasses by the introduced perennial Eragrostis lehmanniana. The Prosopis juliflora in the 1981 photograph was killed by herbicide application in the early 1970's.

Table 1.--Major site-vegetation complexes on the Santa Rita Experimental Range

Dominant shrubs	Annual rainfall	Elevation	Major grass genera	Major soil groups	Slope
	mm	m			%
None (Prosopis has been killed)	380-430	1250-1370	Bouteloua, Aristida, Trichachne	Whitehouse Caralampi Comoro	5-15 10-40 0-10
Prosopis, Haplopappus, Opuntia	254-330	880-1065	Aristida, Bouteloua, Trichachne	Anthony, Sonoita	0-5 1-8
	355-430	1065-1280	Bouteloua, Aristida, Trichachne Heteropogon	Comoro Sonoita Whitehouse	0-5 1-8 10-35
Fouquieria, Calliandra	300-380	1035-1160	Bouteloua, Aristida, Heteropogon	Whitehouse	5-10
Larrea	300	945-1000	Muhlenbergia, Tridens	Anthony	0-5
Acacia, Opuntia, Fouquieria	300-355	1035-1160	Bouteloua, Hilaria Aristida, Tridens	Bernardina Hathaway	2-30 2-30

Forest Service range livestock research will be conducted as a support function to wildlife habitat research. Range livestock research, however, will be emphasized by the University of Arizona and USDA Agricultural Research Service. The principal emphasis will be on (1) a final evaluation of the Santa Rita Grazing System, (2) prescribed burning studies, (3) plant control studies, (4) ecology of Lehmann lovegrass ranges, and (5) fertilization and plant establishment trials. In addition, watershed and animal production studies are planned.

OPPORTUNITIES FOR COOPERATIVE STUDIES

Because the Santa Rita Experimental Range is a public research area, the participation of others interested in arid land environments is encouraged. There are, as would be expected for an area with so many research activities, certain constraints that must be considered. A research study plan must be submitted outlining who is doing what, where, when, and how. This information is necessary for several reasons: (1) to coordinate research so that study areas and treatments do not overlap; (2) to enable us to maintain a historical record of treatments for future reference and to index and protect important transects and photo points; (3) to assist us in describing and defending the research activities on the range to the general public; and (4) to insure compliance

with laws and regulations pertaining to preservation of historical sites and pesticide use.

The USDA Forest Service, specifically the Rocky Mountain Forest and Range Experiment Station, is responsible for these activities. To accomplish this task in the most effective manner we depend on the advice and recommendations of a Research Coordinating Committee, which consists of one member from each of the agencies actively involved in long-term research on the Range (USDA Forest Service, USDA Agricultural Research Service, and the University of Arizona) plus members from other interested groups.

We welcome your ideas and cooperation in making use of the unique facilities of the Santa Rita Experiment Station.

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The Sierra Del Carmens: Mexico's Forgotten Wilderness¹

Roland H. Wauer²

Abstract.--Mexico's Sierra del Carmens (within the state of Coahuila), located southeast of Big Bend National Park, Texas, contains superb mountain scenery and significant natural and cultural resources. Approximately 115 square miles lie above 5,500 feet elevation, and seven peaks rise over 8,000 feet; Pico Centinela is 11,795'. This paper provides a general review of the area's topography and resources and available information base.

We heard the Peregrine tiercel calling to its mate long before we saw it. And we also heard the Peregrine haggard's responsive cries somewhere on the face of the gigantic cliff directly across from our lofty perch. I turned my binoculars toward the deep canyon below and searched for an invisible dot that would be the eyrie-bound hunter. Another call from the depths below somehow directed my search a little to the left. There it was, the tiercel, flying swiftly in a direct course towards the eyrie and its awaiting mate.

I watched that incredible bird with all of the respect it so well deserved. It was returning to its eyrie with food that it had caught in the desert far below. Yet its flight upward was at an angle of at least forty-five degrees. The weight of a bird almost its own size--either a White-winged or Mourning Dove, I could not be certain--did not seem to hamper it. Its powerful wing strokes drove it upward, and in the early morning as it was, few if any thermals provided drafts to ride on as do the broader-winged raptors as the day becomes warmer.

Three of us watched the tiercel every stroke of the way after my first discovery. We knew when it was nearing its eyrie because of the increased calling of both birds. Then suddenly it disappeared from view into a hidden crevice within the rhyolitic fortress. But we understood what was taking place as he shared his kill with his mate and, perhaps, three to four downy youngsters.

A few seconds later the tiercel reappeared, flying out and upward toward the top of the cliff, another 600 feet or so. There, in full view and perched on an old weathered snag, it rested. We watched it preen, ruffle its feathers, and finally settle down as if to stand guard on its Maderas del Carmen homeland.

The Sierra del Carmens form a massive limestone and volcanic range east and south of Big Bend National Park, Texas. It is part of the same geologic past that created the three major topographic structures that jut out of Big Bend's desert landscape (Smith, 1970). In about the center of the 708,000-acre park is a volcanic mountain range known as the Chisos. To the west is a broad limestone mesa that was sliced in half by the Rio Grande to form spectacular Santa Elena Canyon. To the east is another limestone escarpment where Boquillas Canyon was cut by the Rio en route to the Gulf of Mexico. It is that range of mountains that is known as the Sierra del Carmens, and can be further divided into three distinct sections.

The limestone range within the east side of Big Bend National Park, usually called the "Dead Horse Mountains," is a series of arid ridges and valleys. South of Boquillas Canyon the uplifted limestone forms gigantic layers that provide a magnificent backdrop to the park's Rio Grande Village and Boquillas region. South and slightly to the east of these highlands is an even higher series of volcanic peaks that run for about twenty-five miles (Figure 1). It is that part of the range that is known as the Maderas del Carmen, and is the focal point of the description and discussion that follows (Henrickson and Straw, 1976).

Mexico's Sierra del Carmens are more than an extension of the Texas Big Bend Country. They contain all of the same kinds of ingredients that have made Big Bend National Park one of the world's greatest wilderness preserves. It is one of 36 International Biosphere Reserves, established by the Man and the Biosphere Program of the International Union for the Conservation of Nature. Yet the mountains south of the Rio Grande contain an even greater assortment of wildland flora and fauna, cultural resources, and aesthetics.

The Maderas del Carmen suggest that the Chisos Mountains are but a misplaced part. Only 10 square miles of the Chisos lie above 5,500 feet elevation; approximately 115 square miles of the Maderas del Carmen lie above 5,500 feet. Emory Peak, the highest point in the Chisos Mountains, is 7,835 feet above sea level; but there are seven peaks in the Maderas del Carmen over 8,000 feet elevation.

¹Paper presented at the meeting on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States. Rio Rico, Arizona, April 20-24, 1981.

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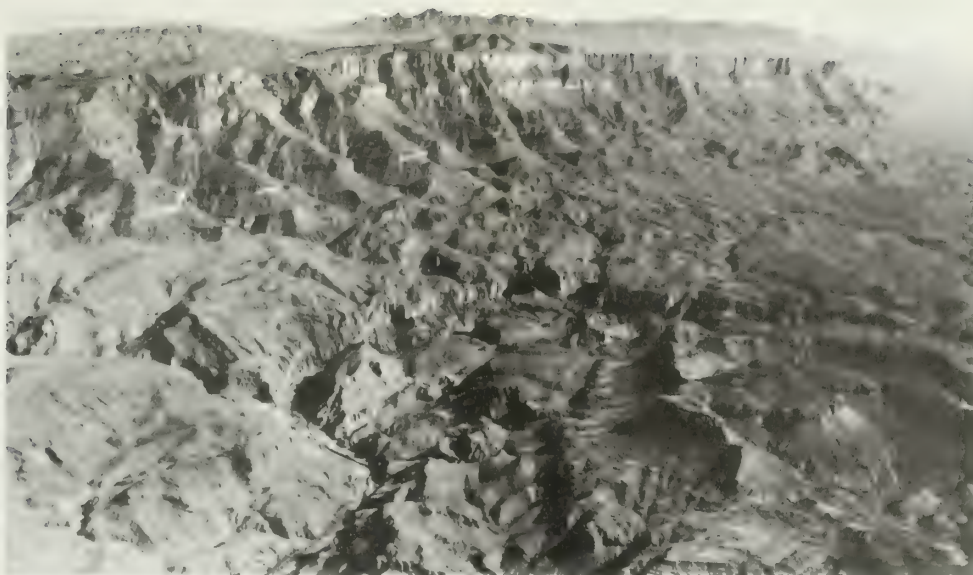


Figure 1. --Mexico's Sierra del Carmen Range consists of a long, banded limestone escarpment and a much higher volcanic mass beyond. In the left foreground, the Rio Grande (International Border) cuts through the limestone ridges to form Boquillas Canyon.

The desert that surrounds the Sierra del Carmens is typical of the arid lowlands throughout most of Coahuila and eastern Chihuahua. For those who understand the desert it is a gentle and exciting place to be. It is more than a harsh environment where summers can be a death trap for the uninformed. It is more than a transition zone between the Rio Grande's line of greenery and the grasslands of the

foothills. It is the start of the mountains. It is the bottom of the pyramid.

On warmer south slopes the grassland belt may occur between 3,500 and 6,500 feet elevation, while it is somewhat narrower on the cooler northside slopes. These grasslands are relatively insignificant on the west side of the del Carmens, however, where the escarpment rises rather abruptly from the desert to the sheer cliffs of the mountain tops. The western escarpment ascends 7,500 feet in less than two miles (Figure 2). But on the east side of the del Carmens the same elevational change occurs in approximately 12 miles. The eastern side, therefore, provides easier access and has experienced much greater use from ranchers, loggers and hunters.

Chisos Agave (*Agave chisosensis*) is found within these grasslands, although until recent years it was considered endemic to the Chisos Mountains of Big Bend National Park (McDougall and Sperry, 1951). And just above the grasslands, on rocky cliffs and ridges, is another agave that occurs only within the mountains of northern Coahuila--the del Carmens, Encantadas and Santa Rosas. This is *Agave totterana*, a heavy-stemmed plant with a beautiful rosette leaf base (H. S. Gentry, pers. comm.). Yellow flowers appear in late July and, like all agaves, the plant dies at the end of the flowering season. It takes agaves from 15 to 35 years to bloom.

A woodland of pinyon pine, junipers and oaks occur above the grasslands (Figure 3). This habitat is minimal on the western side of the mountains, but is extensive on the eastern side of the numerous ridges, mesas and valleys. Fingers of oaks, hackberry and other broadleaf trees follow canyon bottoms to about 4,000 feet elevation. The woodlands occur



Figure 2.--Peregrine Point, viewed here from the west, is one of several del Carmen cliff faces that jut out along the western escarpment.



Figure 3.--Pinyon-juniper-oak woodland occurs above the desert grasslands to about 6,500' elevation. The round rosettes of leaves are Agave totterana.

on drier south slopes up to 7,000 feet. But somewhere around 6,500 feet elevation a more extensive forest begins that runs to the very tops of the highest pinnacles.

The real treasures of the Maderas del Carmens occur in the highlands. There is where the forest crowns the rhyolitic castles and hides the fragile meadows and grassy streams. Southwestern White and Ponderosa Pines blend with an amazing variety of oaks on open flats and ridges, and Douglas-fir and Arizona Cypress are more common in drainages and other protected niches. Coahuila Fir grows in some of the moist out of the way canyons (Muller, 1947).

The rocky crags and canyons are the real attractions that entice the wilderness lovers initially. The southern series of peaks run on almost an exact north-south line for about eight miles. Loomis Peak (8,960') and Peregrine Point (approximately 8,500') are the highest of the series. Although the west face is a sheer cliff for a thousand or so feet, followed by a series of talus slopes and rocky ridges, a high bench drops off suddenly onto Canon del Oso that runs south for almost the total length of the southern peaks.

North of the southern five peaks is another series of peaks and deep canyons (Figure 4) that are just as extensive in length. The northernmost peak dominates the entire northern area. This is Pico Centinela, the highest peak in the del Carmens, that rises to 11,975 feet above sea level. It consists of steep, rocky slopes and sheer precipices. There are no forested benches on Centinela as there are on the southern peaks, but a few patches of Quaking Aspens grow on high talus slopes.



Figure 4.--View northeast from Loomis Peak (8,960') illustrates the rugged character of the northern one-half of the Maderas del Carmen.

The view from the top of Loomis Peak may be one of the finest in North America. The desert lies to the west, below the 2,500 foot escarpment. On a clear day the Chisos Mountains stand out sharply to the northwest. They seem almost touchable but are more than 50 miles away. On dusty days they glimmer like a mirage against the far horizon. To the north are the other peaks of the del Carmens, and the flatland that lies beyond is the top of the limestone part of the range that shows its layered character when seen from the west.

More of the Maderas del Carmen stretches out in a wide semi-circle northeast to southeast from Loomis Peak. There are plateaus and canyons one after another all the way to the desert that lies in long, shimmering north-south troughs. Because of the distance it does not possess individual characteristics like the desert landscape below the cliffs on the west. In a way, the eastern side of the Maderas del Carmen form a series of gradually descending stairsteps that terminate in desert in about twelve miles.

More of the high peaks are visible to the south where they fall sharply off toward the west. And there below the southern rampart are the white scratches of the Los Cohos Mine. Until 1976, access to the highlands was available only by trail from the mine. A rough ore hauling road provided access to that point, at 6,300 feet elevation, and starting place for backpacking into the Maderas del Carmen.

The trail was steep and followed a ridge to below the southern rampart. Near there is Los Cohos Spring, an excellent base camp for exploring the southern portion of the highlands. The trail continued upward to the head of an eastern drainage that is known as either Canon Cinco or Madera Canyon.



Figure 5.--Stipa Meadow provides a sea of grass within the ponderosa pine and oak forest.

This canyon contains an old road that can be followed eastward all of the way to the desert.

Near the top of Madera Canyon is a straw-colored meadow (Figure 5). Except for an assortment of wildflowers at various seasons, needlegrass is by far the most common groundcover. A slight breeze ripples the tawny stems like a field of summer wheat. But this field was not planted by man. It is a product of the rains, the soils, and wildfires. The meadow grass feeds deer, pocket gophers, and a variety of rodents. One of these--the yellow-nosed cotton rat--occurs only in meadows of needlegrass. In places left unabused, and where nature is still the control.

The meadow is a good place to camp, but man's presence there in the natural cathedral is out of place. It is not a place for many to stay, only to pause and admire the lush grass and coniferous backdrop. And the meadow's position within Madera Canyon is tentative in comparison with the cliffs that stand above the surrounding forest.

I discovered a mountain lion stalking a deer in the meadow on one trip. My sudden appearance frightened the lion from its venison meal.

The deer of the Sierra del Carmens is a small race of white-tail named after these mountains. They occur only in the del Carmens and Chisos, usually above 4,500 feet elevation. The two populations once were contiguous, but the desert now separates the two land islands (Wauer, 1973; Krausmann, 1976).

Dr. Phillip Wells (1979) studied woodrat "middens" (pack rat dens) found within dry overhangs in the foothills of the Chisos and Dead Horse Mountains, and reported finding pieces of pinyon in layers of his "middens" that were more than 20,000 years old. According to his chronology, until about 10,000 years ago, the woodrats lived in a woodland environment quite similar to



Figure 6.--Douglas-fir, southwestern white pine and Coahuila fir dominate the forest in Canon del Oso.

that of the mountain woodlands today. Then the vegetation began to change to a more zeric type and finally to true desert. His studies suggest that the Chihuahuan Desert invaded the Big Bend area as late as 9,000 or so years ago.

Since the Sierra del Carmen white-tails live only in woodland and forest habitats, the population divided and followed the tree line upward when the desert became established. Today, the Chisos and del Carmen Mountains are like two islands surrounded by an ocean of desert. And sometime in the last few thousand years mule deer have moved into the lowlands.

My favorite place in the del Carmens is Canon del Oso. It is the most green and peaceful of all the beautiful canyons within the Maderas del Carmen. On the canyon floor is a stream that slows between grassy banks and trickles over rocky ledges. Numerous pools are spaced here and there where mossy boulders have lodged on some previous high water to dam a place or form a new meander.

The canyon is narrow, and in one place volcanic "gates" form an hourglass. There are two or three places along the three-mile stretch where the stream disappears into the sandy bottoms. But the abundance of vegetation throughout is convincing evidence that surface flow is just beyond (Figure 6).

It is impossible to know what the Maderas del Carmen was like during the centuries before the first loggers cut the forest. I believe that the Imperial woodpecker lived within these forested highlands. And I cannot help but wonder what other forms of life will be destroyed by the new logging activities.

The birdlife of the Sierra del Carmens has been most interesting to me. For the most part, I found it similar to that of the Chisos mountains (Wauer,

1974). But there are a number of significant differences. The greater variety of breeding raptors is, undoubtedly, the result of the wild conditions and much larger land mass. Golden eagles, redtails, zone-tailed and Cooper's hawks, and peregrines nest. One night I heard four kinds of owls calling near Los Cohos Spring: screech, flammulated, pygmy and saw-whet. Great horned and elf owls nest lower down the mountain.

In the forest, I cannot help but be impressed with the similarity of the birdlife to that of the Chiricahuas in southern Arizona. Brown-throated wrens are abundant and seem to sing from every pile of downed logs and brush. Yellow-eyed juncos are just as numerous within the forest. Pygmy nuthatches are common in the stands of ponderosa pines. And high in the foliage of pine and fir are olive warblers. In more open places painted redstarts busy themselves flycatching in typical redstart manner.

In the high, grassy meadows I have awakened in the very early morning to low whistles (a descending call like that of a hypothetical canyon wren/screech owl hybrid) of a Montezuma quail. Never have I found this beautiful cyrtornis as abundant as it is in the Maderas del Carmen. The theory that this species does better on ranchlands in the United States is refuted by the del Carmen population. It must reach its greatest abundance in these mountains.

Seventy-three kinds of birds are known to nest within the Sierra del Carmens. Some of the common birds of the highlands include band-tailed pigeon, whip-poor-will, white-throated swift, common flicker, western flycatcher, violet-green swallow, Mexican jay, black-crested titmouse, canyon and rock wrens, Hutton's vireo, hepatic tanager, black-headed grosbeak, and lesser goldfinch (Wauer, 1974).

During the pre-Big Bend National Park days of the 1930s, a grand plan for an International Park that would include the mountains and desert on both sides of the Rio Grande was high on the minds of U.S. officials and other interested persons. Early park planners made a serious attempt at encouraging special status for the Sierra del Carmens. The U.S. National Park Service sent biologists to both sides of the river to make initial surveys. Botanist Ernest G. Marsh, Jr., visited the del Carmens and prepared a report entitled, "Biological Survey of the Santa Rosa and del Carmen Mountains of Northern Coahuila, Mexico" (1936).

Even after 1943, when Big Bend National Park was established, biological surveys continued. As part of an ecological study of the new Texas park, a team of scientists that included Walter P. Taylor, Walter B. McDougall, Clifford C. Presnall, and Karl P. Schmidt visited the northern half of the Sierra del Carmens in spring 1945 (1946).

A Mexican National Park was designated during the 1970s, but the area receives no administration or protection. Local residents are unaware of park status. The Sierra del Carmens, today, appears to be a forgotten wilderness.

ACKNOWLEDGEMENTS

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Moderator's Comments: Current Research Strategies¹ for Range and Wildlife Management

Eng. Juan Jose A. Reyes Rodriguez²

To give you the general framework of wildlife management and research in Mexico, let me show you the function of the Federal Government and its relationships to State Government and other private and public institutions.

Article 27 of the political constitution of the Mexican United States of 1917 (the official name for Mexico) established clearly that the natural elements of the country subjected to exploitation and appropriation are owned by the Nation. The Federal Government may create private property, and conduct and set all dispositions that could modify the private interest under conditions of the public interest.

This article made it possible to promulgate Federal laws that specifically regulate the natural resources of the country. Examples include the Federal laws for water, agrarian reform, forestry, and hunting. Because these laws are of public interest and general observancy, they are above of all other laws and regulations. Under this legal framework, the Federal Government is the authority responsible for management, conservation, administration, improvement and exploitation of forestry and wildlife resources in the whole country.

For the administration of such resources, the Executive Branch of the Government established the Department of Agriculture and Hydraulic

¹Paper presented at the workshop on wildlife and range research needs in northern Mexico and southwestern United States, Rio Rico, Arizona, April 20-24, 1981.

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Resources, with five Suboffices and several Head Offices, among these is the Subsecretary of Forestry and Wildlife, which has several Direcciones Generales. The Direccion General De La Fauna Silvestre is responsible in the country for the administration (in its general concept), management, and use of the wildlife resources. The National Institute for Forestry Research and the Direccion General for Forestry Surveillance and Control are responsible for research and surveillance respectively for forestry resources. They were recently given the same responsibility for wildlife resources in order to support and help the Direccion General De La Fauna Silvestre in its own duties.

The Direccion General De La Fauna Silvestre is establishing a general wildlife management plan for the country. This plan sets the objectives, goals, strategies, programs, and projects to be accomplished in the short and long term.

The main objectives for wildlife resources management are administration, preservation, conservation, and exploitation of wildlife, as well as promotion and organization of the users and producers of wildlife resources.

Under this "umbrella", the purpose for wildlife management will be supported by the research and surveillance developed by the respective administration units on one hand. On the other hand, the participation of the users, conservationists, hunters, and managers of wildlife, as well as private institutions, will also help conserve our wildlife.

Now we are going to proceed with the presentation of different dissertations which will explain what the situation is in the southwestern United States and in northern Mexico.

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The Forest Service Program of Range and Wildlife Habitat Research in the Southwest¹

David R. Patton²

Abstract.--Within the Rocky Mountain Forest and Range Experiment Station there are 9 field locations with 27 Research Work Units. Units that have the responsibility of doing range and wildlife habitat research in the Southwest are located at Lubbock, Texas; Albuquerque, New Mexico; and Tempe and Flagstaff, Arizona. Research includes determining the effects of livestock grazing on wildlife habitats, habitat requirements of fish and wildlife, developing habitat management systems.

This workshop provides an excellent opportunity to exchange ideas about range and wildlife research problems in northern Mexico and the southwestern United States. Scientists in both countries have had individual contacts through their respective agencies and departments for many years, but only in the past few years have there been efforts to get together to discuss ways to solve some of our common problems. I hope our work this week will be the start of many efforts in exchanging information, exchanging personnel, and conducting joint research projects.

To understand how the Forest Service determines what the problems are in the Southwest and how research priorities are set, it is necessary first to understand the organizational structure and research responsibilities.

ORGANIZATION STRUCTURE

The Forest Service is an agency of the Department of Agriculture (fig. 1). The Chief of the Forest Service reports to the Assistant Secretary for Natural Resources and Environment, who in turn is responsible to the Secretary of Agriculture in the Executive Branch under the President. The Forest Service is a line staff organization whereby the line officers are the decisionmakers (policy, program direction, etc.)

¹Paper presented at "A Workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States." Rio Rico, Arizona, April 20-24, 1981.

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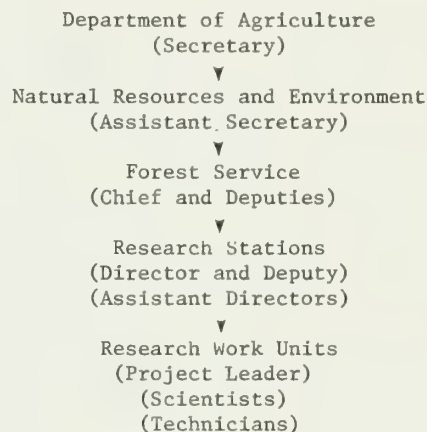


Figure 1.--Abbreviated Forest Service organizational structure for research.

while the staff officers provide the support (budget, personnel) and background information to make the decisions.

Research is organized into nine geographically dispersed Experiment Stations. Within each Experiment Station the actual research is done at the Research Work Unit (RWU) level. Work Units consist of a Project Leader and one or more scientists and technicians. Most Research Work Units are located at various colleges and universities throughout the United States. Within the Rocky Mountain Forest and Range Experiment Station there are 9 field locations with 27 Work Units.

Authority for the Forest Service to do research is contained in several laws enacted by Congress. These laws do not restrict research to

only those lands administered by the Forest Service in the National Forest System, but provide broad authority to cooperate and do research on other Federal, State, or private land. Where common problems exist on lands administered by different agencies, cooperation by sharing personnel, funds, and information is encouraged, generally through written agreement between the agencies.

Congress provides funding for research each fiscal year (October to September) as part of the President's budget. Requests for funds are developed by each Experiment Station, and are based on the need to add to, delete from, or continue a research program. Congress can change the amount of the funds requested and can change the direction of the research program by providing specific wording in an appropriation bill.

DEVELOPING A RESEARCH PROGRAM

Each Research Work Unit has a Research Work Unit Description (RWUD) that outlines the research mission and assigned problems (fig. 2). This document is the authority for the Unit to do research and must be approved by the Experiment Station Director and Deputy Chief for Research in Washington. Unit descriptions are written for a 5-year period but can be amended earlier if needed. Once a RWUD is approved there is a process of analyzing the assigned problems and documenting specific studies that will be done during the research period. The final objective, of course, is to do research and provide information for use by resource managers and others.

The process of determining research problems is a continuing one, but actual documentation starts about a year before a new RWUD is drafted. The importance of problems is determined by discussing research needs with people that are actually managing the resource, such as biologists, foresters, and range conservationists. At the same time planning documents from colleges, universities, and other Federal and State agencies are reviewed to provide additional insight into problems of all land managers within the assigned research area--which in our case is Arizona, New Mexico, and West Texas. From discussions and reviews, problems with relative priority begin to emerge. Other factors that have to be considered are research needs that may have been set because of national legislation, or direction that has been determined by the Experiment Station to meet priorities.

The end product from all reviews and discussions is a draft document outlining resource problems that need to be solved through research. Based on the available financing and number of scientists to do the work, alternatives are listed for several sets of problems. These problem sets are then reviewed within and outside the Forest Service so that research priorities can be selected that are important to more than one agency or area.

Research Work Unit Description

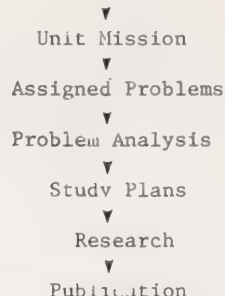


Figure 2.--Hierarchy of events from RWUD approval to publication of results.

Once the priorities and problems have been selected, a problem analysis is written. This analysis explains in detail why the problem exists and how it will be solved by one or more studies in the 5-year research period. Although the process from Research Work Unit Description to Study Plan may appear time-consuming and laborious, it does assure that research is planned, done in an orderly manner, and on high-priority problems.

THE RESEARCH PROGRAM

Range and wildlife research in the Southwest (Arizona, New Mexico, and West Texas) is the responsibility of Research Work Units at Lubbock, Texas; Albuquerque, New Mexico; Tempe and Flagstaff, Arizona. These four units have 12 scientists working on problems in low-elevation hot deserts, in cool ponderosa pine forests, and in high-elevation alpine conditions. The problems assigned to the four units are quite variable and reflect the differences in number and expertise of scientists, support services, financing, and types of problems. A brief review of the assigned problems will provide information needed for the Working Groups in Session III.

Lubbock, Texas

The mission of the Lubbock Unit is to develop wildlife conservation and habitat management methods to increase income from the land, to develop recreational opportunities, and to improve amenities. This Unit, which does research mostly on private land in the Southern Great Plains, has three problem areas: (1) to assemble, integrate, evaluate, and make readily available the current economic and biological information relevant to management of wildlife, (2) to assess habitat management potentials and to develop management guidelines for key migratory, upland, and big game species, and (3) to evaluate the socio-economic potentials and opportunities for wildlife resource development on private land.

Twenty percent of the Unit's effort is directed to solving Problem 1, which considers

mule deer, pronghorn, and ring-necked pheasant, and how lease hunting of these species adds to the economy of the region. Problem 2 focuses on species that are associated with playa lakes and the habitat needs of big game species. This problem accounts for about 40% of the Unit's research. Problem 3 emphasizes the use of habitat on private land as an economic enterprise. Research includes determining ways that landowners might profitably implement management and lease land for hunting.

Albuquerque, New Mexico

The mission of the Albuquerque Unit is to develop methods for the rehabilitation and management of disturbed sites. Two problems are assigned to the Unit: (1) develop methods to establish and maintain a productive ecosystem of plants on southwestern coal and uranium mine spoils, and (2) improve productivity and soil stability of semiarid rangelands.

Problem 1 is directed to finding plants that are adaptable for reclaiming land, developing seeding and planting methods, designing soil stabilization techniques, and determining methods of managing reclaimed sites for livestock and wildlife. Problem 2 emphasizes research on ways to use and improve degraded semiarid rangelands. Vegetation, soils, and wildlife populations are being studied to determine their responses to different grazing systems. Part of the work will include research on range site classification.

Tempe, Arizona

The mission of the Tempe Research Work Unit is to develop procedures and systems for predicting the effects of land management practices on the quality of wildlife habitats, and to provide managers with information on wildlife habitats and populations to meet the requirements of the National Forest Management Act, Resources Planning Act, and Threatened and Endangered Species Act. Two problems are assigned to the Unit: (1) to develop data to solve regional and national issues about management of riparian vegetation, restoration and management of threatened and endangered species, and to reduce conflicts involving livestock and wildlife interactions, and (2) to develop adequate systems for managing wildlife habitats, and technology to define diversity and indicator species.

Problem 1 contains three parts, two of which are national issues: riparian habitat and endangered species. A great diversity of bird life in Arizona and New Mexico is produced in riparian vegetation which crosses the entire range from mountains to deserts. One endangered species, the bald eagle, depends on riparian vegetation to meet its food and cover requirements. The third part of the problem relates to livestock use of National Forests and Grasslands, which amounts to 2 million animal unit months on 18 million acres. Livestock in the Southwest has economic importance

to individual ranchers, the local community, and the region. However, wildlife also provides economic and aesthetic values, and needs to be considered when determining carrying capacity and resource tradeoffs.

Problem 2 focuses on the need for information to make management decisions. Emphasis will be on improving a current data base management system known as RUN WILD, and developing a habitat classification system for grouping animal species with similar feeding and breeding requirements. This problem also directs attention to the development of simple, easy-to-use habitat models.

Administration of the Santa Rita Experimental Range is also part of the work of Tempe's Wildlife Research Unit. This 50,000-acre outdoor laboratory is maintained for research on desert ecosystems. Research is conducted in cooperation with universities, other State and Federal agencies, and private livestock owners.

Flagstaff, Arizona

The mission of the Flagstaff Unit is to facilitate multiresource management of southwestern ponderosa pine, pinyon-juniper, and related forests through the development, advancement, and transfer of knowledge and technology useful in formulating, simulating, and comparing alternatives. Four problems are assigned to the Unit, and all four consider range and wildlife: (1) develop knowledge about biophysical and socio-economic effects of activities in forests and woodlands of the Southwest for evaluation of alternative management practices, (2) develop and synthesize knowledge of processes controlling onsite and offsite biophysical effects of management activities in southwestern forest ecosystems, (3) develop improved tools and techniques for evaluating tradeoffs among multiresource management alternatives in terms of their biophysical and socio-economic effects, and (4) develop adequate tools and procedures for formulating, simulating, and comparing land and resource management alternatives at the forest level.

The first problem is one of studying experimental watersheds to determine how land management activities affect resource outputs, including wildlife habitat, forage production, water yield, and timber production and quality. Problem 2 focuses on developing new process models or modifying existing models so they can be used in the Southwest. Problem 3 deals with evaluating the economic tradeoffs of managing forests to produce more or less of one resource while at the same time increasing or decreasing other resources. The fourth area of research involves the development of Ecosystem Component Simulation Models (ECOSIM) in a modular form to include flora, fauna, water, sediment, nutrients, etc. The intent is to link all modules together for analysis and display in user-oriented systems.

Table 1.--Research Work Unit location and problem
category of research in the Southwest.

Problem Category	Lubbock	Albuquerque	Tempe	Flagstaff
1. Effects of live-stock grazing on wildlife habitats	X	X	X	
2. Habitat requirements of fish and wildlife	X		X	
3. Develop habitat models			X	
4. Develop process models				X
5. Riparian ecology			X	
6. Develop grazing systems		X	X	
7. Land rehabilitation		X		
8. Develop data base or systems of management			X	X
9. Economic evaluations of habitat	X			X
10. Waterfowl habitat	X			
11. Plant autecology		X	X	

A major part of the data used by the Work Unit comes from the Beaver Creek Watershed where there is a cooperative effort involving other Work Units, colleges and universities, and the Arizona Game and Fish Department. Dave Garrett has already provided a detailed account of Beaver Creek in Session II on Biosphere Reserves.

SUMMARY

The range and wildlife habitat research program in the southwestern United States is an important part of the total Forest Service research effort because many of the problems have regional or national significance. Table 1 categorizes the problems assigned to the four southwestern Research Work Units. Most of the

problems can be classified as applied research, reflecting a strong commitment to solving the problems of the land manager. Individual studies under the listed problems are being done in a variety of vegetation types and climactic regimens.

Although not shown in the table, many of the problems contain cooperative research studies with other Federal and State agencies. This cooperative approach is an efficient method to solve problems in a shorter time and with less funds than by doing the research entirely within one agency. Some of the research we are doing and some of the problems we have identified for the southwestern United States are equally as important in northern Mexico. Our Research Work Units look forward to cooperating to solve our common problems.

National Park Service Scientific Activities in the Southwestern United States¹

William P. Gregg, Jr.²

Abstract.--The National Park Service, which administers 16 major ecosystem conservation areas in the southwestern United States, plans a significant expansion of scientific activities to address internal and external threats to natural ecosystems.

In its landmark report outlining a world conservation strategy for continuous renewal of the benefits the biosphere provides to present and future generations, the International Union for the Conservation of Nature and Natural Resources underscored the urgency of undertaking a major global initiative to reverse the trend of declining dryland productivity, commonly referred to as desertification (I.U.C.N. 1980). The demands of growing human populations for food, fiber, fuelwood, habitation sites, fossil fuels, hardrock minerals, and other commodities have vastly exceeded the ecological tolerance of the world's arid and semi-arid lands, to the point where more than two billion hectares are reported to be at high or very high risk of desertification. In North America, severe desertification is estimated to affect 37 percent of the continent's dryland area, predominantly in the warm desert ecosystems of the southwestern United States and Mexico (Council on Environmental Quality 1981). Considerable losses in agricultural productivity and economic return on agricultural investment have already occurred. Longstanding problems of soil erosion, salinization, and ecologically and economically adverse vegetation changes due to overgrazing are being augmented by the effects of large-scale urbanization, industrialization, and the associated influx of human population. Because of the rapid pace of these changes, the full implications of their effects on the natural ecosystems, social conditions, and economic productivity of the region are imperfectly understood. Yet it is obvious that informed multidisciplinary scientific perspective on the nature and significance of these interacting effects will be a key factor in developing policies and land use strategies for meeting economic development objectives in a manner

which conserves the productivity of dryland ecosystems and optimizes the quality of life for people that depend upon them.

The Department of the Interior, in cooperation with other agencies, is taking an important step in the development of this perspective. An assessment of the state of our knowledge of the interrelated ecological, social, economic, legal, and institutional factors related to desertification is nearing completion, with a draft report scheduled for release in the early summer of 1981. The assessment is being prepared as a major element of the United States' response to the United Nations Conference on Desertification (Nairobi, August 29 - September 9, 1977), which recommended a global plan of action to deal with the problem. While not a panacea, the report should provide valuable support for the unprecedented institutional cooperation which will be needed to develop and implement effective actions to abate, and eventually reverse, the desertification process.

Conservation of protected ecosystems in the southwestern United States during the next decades will require progressively more emphasis on developing management strategies for dealing with the growing diversity of human influences originating from both inside and outside the protected areas themselves. Effective strategies will increasingly depend upon the ability of the land manager to detect and evaluate ecological changes at the population, community, and ecosystem levels; to determine whether observed changes are the result of natural processes or human influences; and to take cost effective, legally defensible measures to deal with scientifically documented threats. This will require unprecedented attention to the selective acquisition of information which provides accurate and reliable indications of ecological change and the relative contributions of its casual factors. As budgetary constraints and personnel ceilings typically will prevent the unit manager from developing the multidisciplinary capabilities needed for even a highly selective in-house science program,

¹Paper presented at a workshop on wildlife and range research needs in northern Mexico and southwestern United States, Rio Rico, Arizona, April, 20-24, 1981.

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innovative integration of the sectorial capabilities of diverse agencies and institutions will likely become the modus operandi for obtaining scientific information in a cost effective manner. One of the most effective ways to tap these capabilities is to emphasize the progressive integration of the protected units into science and resource management programs which are regional or national in scope, where economies of scale can enable the accomplishment of work in the protected area which would otherwise be difficult or impossible for the unit manager to carry out.

The protected areas of the southwest are well integrated into a large number of national programs for the collection, analysis, and interpretation of data on the physical environment, which enable evaluation of trends and events so often implicated as causes of ecological change. Stations for monitoring weather, air quality, stream flow, water quality, and wetfall and dryfall deposition are established in many areas and provide data to national systems. Costs to the land manager for installation, and operation of equipment, training of technicians, and data analysis and interpretation often are wholly or partially absorbed by the national system administrator because the data sets improve the geographic or resource coverage of the monitoring network and therefore its value as an assessment tool.

Just as the remote location and ecological integrity of many protected natural areas has already made them particularly valuable as baseline areas for monitoring physical parameters, so must these characteristics inevitably increase their future value as control areas for experimental research focused on rehabilitation and improved management of culturally manipulated ecosystems. In no other region of the United States is this value likely to be as great as in the southwest, where regional desertification has dramatically increased the scientific and educational potential of the relatively modest number of natural ecosystems which have been effectively protected and subjected to ecological study during the last 20-30 years of rapid land use and environmental change.

NATIONAL PARK SYSTEM AREAS IN THE WARM DESERTS

The National Park Service presently administers 16 major ecosystem conservation units in the warm desert and adjacent areas of California, Nevada, Arizona, New Mexico, and Texas, each exceeding 4,000 hectares in size (Table 1). Together, these units total 2.9 million hectares. They include most of the characteristic ecological communities of the Sonoran and Chihuahuan Biogeographic Provinces, and limited representation in the northern portion of the Madrean-Cordilleran and Tamaulipan Provinces and extreme southern portions of the Great Basins and Rocky Mountain Provinces (Udvardy 1975). As a group, the units illustrate a remarkably long history of continuous

protection. Fourteen units have been protected for more than 40 years, and even the most recent addition, Guadalupe Mountains National Park, has been under protective management for 15 years.

In the United States, wilderness designation by the Congress conveys the most secure form of legal protection available to natural ecosystems. The southwestern desert units contain a particularly strong representation of these legislatively designated areas, which are managed strictly to minimize human disturbance and perpetuate natural ecosystems. Ten of the units contain designated wilderness areas or areas awaiting congressional action (and currently managed as wilderness), which collectively comprise 1.4 million hectares, or nearly half the total conservation area.

Although these protected ecosystems are affected by many internal and external human influences, they nevertheless provide the most extensive land management system in the region for the conservation of genetic and habitat diversity, and provide many of the most suitable control sites for ecological research.

Because of their long history of protection, most of the southwestern units have received considerable scientific study. Some, such as Big Bend National Park, have excellent long-term information on the status of biological resources based on periodic natural history surveys, population studies, and sampling of permanent plots. However, as the development of an integrated ecosystem-oriented research program has not traditionally been a priority objective of the unit manager, most scientific studies have been directed toward providing a basic description of natural history, addressing immediate management problems, and--in the case of many university studies not directly supported by the bureau--fulfilling the particular research objectives of individual investigators.

In recent years, the bureau has increased its emphasis on multidisciplinary planning to establish resource management objectives and cost effective strategies for dealing with internal and external influences. Nearly all of the southwestern desert parks now have an up-to-date natural resources management plan, which identifies, prioritizes, and integrates scientific and management projects needed to address both immediate and long-range management requirements. The plans provide the framework for coordinating activities in the park and surrounding region in order to improve the quality of management in the unit itself and simultaneously improve the value of the unit in regional scientific, educational, and management programs. Resource management planning is a continuing process conducted at the field level, and the plans are readily revisable to accommodate changing conditions.

Table 1.--Major ecosystem conservation areas more than 4,000 hectares in size administered by the National Park Service in warm deserts of the southwestern United States

Name of area	Year of authorization ¹	State(s)	Area in hectares	Wilderness area in ² hectares	Biogeographic province
Amistad National Recreation Area	1965	Texas	25,273	---	Tamaulipan
Bandelier National Monument	1916	New Mexico	14,962	9,416	Rocky Mountain
Big Bend National Park	1935	Texas	286,565	217,834 ³	Chihuahuan *(Biosphere Reserve)
Canyon de Chelly ⁴ National Monument	1931	Arizona	33,929	---	Great Basin
Carlsbad Caverns National Park	1923	New Mexico	18,921	13,405	Chihuahuan
Chaco Canyon National Monument	1907	New Mexico	8,704	---	Chihuahuan (transitional to Great Basin)
Chiricahua National Monument	1924	Arizona	4,487	3,821	Madrean-Cordilleran
Death Valley National Monument	1933	California Nevada	836,808	772,141 ³	Sonoran (Mojave/Great Basin transitional)
Grand Canyon National Park	1893	Arizona	493,059	study in progress	Sonoran (Mojave/Great Basin transitional)
Guadalupe Mountains National Park	1966	Texas	30,835	19,769	Chihuahuan
Joshua Tree National Monument	1936	California	226,608	173,890	Sonoran (Mojave)
Lake Mead National Recreation Area	1936	Nevada Arizona	605,653	study in progress	Sonoran (Mojave)
Organ Pipe Cactus National Monument	1937	Arizona	133,825	126,502	Sonoran *(Biosphere Reserve)
Petrified Forest National Park	1906	Arizona	37,835	20,349	Sonoran (Great Basin transitional)
Saguaro National Monument	1933	Arizona	33,822	28,895	Sonoran
White Sands National Monument	1933	New Mexico	58,444	---	Chihuahuan

¹Year of congressional authorization, Presidential proclamation, cooperative agreement, or administrative transfer conferring protective status on natural ecosystems.

²Legislatively designated areas and areas pending congressional action.

³Pending congressional action; presently managed as wilderness area.

⁴Administered in accordance with agreement with the Navajo Nation.

THREATS TO NATIONAL PARK SYSTEM AREAS

A growing national awareness of the potential consequences of rapidly changing conditions resulted in a congressional request for the National Park Service to prepare a report identifying and characterizing threats to the natural and cultural resources of the National Park System. In response to this request, the Service conducted a survey to assess the perceptions of managers, scientists, and planners as to the nature and sources of the threats, and the resources endangered by the threats. Threats were defined as internal and external influences which "have the potential to cause significant damage to park resources or to seriously degrade park values or park experiences" (National Park Service 1980). In its May 1980 report to the Congress, the Service summarized the survey results and underscored the need for new initiatives and major expansions of existing science programs to develop the capability to understand and deal with these complex interacting influences.

Although the perception of threats in individual units varied depending upon the professional training and experience of the respondents, the survey provided a useful overview of existing and suspected anthropogenic influences on park ecosystems. A few of the more salient conclusions were:

*The 63 large natural areas greater than about 12,000 hectares reported twice the average number of threats as the Servicewide norm. A large proportion of the threats reflected a strong awareness of the impacts of land use changes in the surrounding region.

*More than half the reported threats were due to external influences, predominantly associated with regional land use changes.

*Units designated as Biosphere Reserves reported the greatest mean number of threats (36.3)--about three times the Servicewide norm (13.6). Although the greater perception of threats may be due to greater emphasis on long-term monitoring in these research-oriented areas, this finding is nevertheless significant because it suggests the diversity of influences which may already be affecting some of the world's most suitable control areas for ecological research.

*Fully 75% of the reported threats were considered to be inadequately documented through scientific study.

Table 2 summarizes the reported threats for the large natural area parks in the southwest. The mean number of reported threats was 27.5, about twice the Servicewide norm, and about 20% above the average for all natural area parks larger than 4,000 hectares. All 73 of the surveyed threat categories were perceived as existing in at least one of the parks. Of the

16 parks, all reported aesthetic degradation as a known threat; 15 reported physical removal of natural resources; 14 reported encroachment from exotic physical or biological sources; 13 reported threats from air pollution and 13 from the activities of visitors; 10 reported threats from park operations; and 9 from water pollution or hydrological factors. Where one of these major types of threats was reported, multiple sources were perceived to be involved in all but a few of the cases. Approximately 65% of the reported threats were considered to be wholly or partially associated with external sources. This figure exceeds the Servicewide mean for all threats by 10%, and exceeds the mean for air pollution threats by 11% (99 vs 89% external), aesthetic degradation threats by 17% (78 vs 61%), and water resources threats by 22% (92 vs 70%). These perceptions may reflect an elevated significance of environmental and ecological changes associated with rapid urbanization and industrialization of the Sun Belt region.

Threats to large southwestern parks were more often reported as adequately documented by research (33%) than for the National Park System as a whole (25%), and less often reported as known but in need of scientific documentation (28 vs 42%). These results may reflect the utility of the long history of scientific investigation in enabling threats to be characterized in many areas. However, the majority of all known and suspected threats nevertheless were considered to require research to provide adequate documentation--91% for air pollution, 78% for water pollution, 73% for visitor impacts, 66% for park operations impacts, 62% for physical removal of resources, 59% for exotic encroachment, and 52% for aesthetic degradation.

In the southwest, as elsewhere, the survey has documented the many human influences which endanger protected natural ecosystems, and pointed out the critical need for baseline inventory to describe existing conditions, monitoring to detect and quantify changes, and research to demonstrate cause and effect relationships. Although of limited value in individual units, the survey has been a valuable catalyst for new programmatic initiatives to develop the needed scientific information base.

SCIENCE PROGRAM INITIATIVES

An important near-term initiative focuses on major expansion of research activities in parks selected on the basis of the significance and representativeness of their ecological resources, the significance and imminence of threats, and the identified needs for scientific information. The initiative is the first step in the development of an integrated long-term program to increase the manager's ability to evaluate and respond to human-caused threats to biological resources. Most of the targeted parks are Biosphere Reserves which, in addition

Table 2.--Summary of known and suspected threats to major natural area units of the National Park System in the warm deserts of the southwestern United States, based on 1980 National Park Service survey

NAME OF PARK UNIT

	THREAT CATEGORY	AMISTAD NRA	BANDERILLER NM	BIG BEND NP (RIO GRANDE)	CANYON DE CHELLY	CARLSBAD CAVERNS	CHACO CANYON NM	CHIRICAHUA NM	DEATH VALLEY NM	GRAND CANYON NP	GUADALUPE MTS NP	JOSHUA TREE NM	LAKE MEAD NRA	ORGAN PIPE NM	PETRIFIED FOREST	SAGUARO NM	WHITE SANDS NM
AIR POLLUTION	Smoke	-	Se	Ne	-	Se	Ne	Se	Ne	-	Se	Ne	Ne	Ne	Ne	Ne	Se
	Acid Rain	-	Se	-	-	Se	Se	Se	-	Se	Se	-	-	Se	-	-	-
	Chemical Particulates	-	-	Se	De	-	Ne	Se	Se	De	-	Ne	Se	Ne	-	-	Se
	Dust	-	Die	Ne	-	De	Nie	-	Ne	De	Se	Ne	Se	Ni	-	Nie	Nie
	Hydrocarbons	-	Se	Se	-	-	-	-	Se	Si	-	Se	Se	Si	-	Ne	-
	Odors	-	Se	Se	-	-	-	-	-	-	-	-	-	-	-	-	-
	CO	-	-	-	-	Se	Se	Se	Se	Si	-	Se	Se	-	-	Ne	-
	NO _x	-	-	-	-	-	Se	Se	Se	De	-	Se	Se	Se	-	Se	-
	CO ₂	-	-	-	-	-	Se	Se	-	-	-	Se	Se	-	-	Se	-
	Fog	-	Se	Si	-	-	-	-	-	-	-	-	-	-	-	-	Se
	Radioactivity	-	De	-	-	Di	Se	-	Se	Si	-	-	Se	-	-	-	-
WATER POLLUTION	Organic	-	-	Se	-	-	-	-	-	Die	-	-	Ne	-	-	-	-
	Flood/Flow Decrease	-	Die	Ne	-	-	Ne	-	Se	De	-	Die	De	Ne	-	-	Se
	Toxic Chemicals	-	Se	Se	-	Se	Se	-	-	Se	Se	-	Se	Ne	-	-	Se
	Inorganic	-	-	-	-	-	-	-	-	Se	-	-	Se	-	-	-	-
	Salt/Sediment Deposition	-	Die	-	-	-	Se	-	Di	-	-	-	Ne	-	-	-	-
	Oil Spills	-	-	-	-	-	De	-	-	Se	-	-	Si	-	-	-	-
	Acid Mine Drainage	-	-	-	-	-	-	-	Se	-	-	-	-	-	-	-	-
	Radioactivity	-	-	-	-	-	-	-	Si	Si	-	-	Si	-	Se	-	-
	Other	-	-	-	-	-	Se	-	-	-	Die	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AESTHETIC DEGRADATION	Land Development	Ne	Ne	Ne	-	De	Se	De	Ne	Ne	Se	De	-	De	Ne	De	Ne
	Utility Access	Ne	De	Di	Di	-	Se	-	-	-	-	De	Di	De	De	De	Ne
	Roads/Railroads	Ne	De	-	Di	-	Se	-	-	Si	-	-	Ni	Ni	De	De	Se
	Overcrowd/Vandalism	-	Die	-	-	Di	Se	-	Ni	Si	-	Di	Si	Ne	-	Die	-
	Urban Encroachment	Ne	Se	-	Di	-	-	-	Se	-	-	De	Se	Ne	-	De	-
	Vista	-	-	-	-	De	-	-	-	-	-	Di	-	-	-	Ne	-
	Minerals	-	-	Se	-	Se	De	Se	Die	Di	Se	De	Si	-	Se	Ne	-
	Forest: Disease, Pests	-	Die	Di	-	-	Se	-	Di	-	Si	-	-	-	-	-	-
	Grazing/Agriculture	Ne	-	Ni	-	De	Se	-	De	Di	De	-	Si	De	-	Se	-
	Wildland Fire	-	Die	Di	-	Die	Se	D	Di	Die	Die	-	-	Ne	-	Di	-
	Logging	-	Ne	-	-	-	Se	-	-	-	-	-	-	-	-	-	-
PHYSICAL REMOVAL OF RESOURCES	Soil Erosion	Si	Die	Ne	Die	-	Die	-	-	-	-	-	-	Ni	-	-	Se
	Illegal Arch. Collect	Se	Di	Ni	-	Se	De	-	-	Si	Se	Di	-	Se	-	Ni	Ne
	Hunt/Poaching	Se	Die	Nie	-	De	-	-	Ni	De	Di	Si	-	-	-	-	-
	Grazing	Ne	Di	Ni	Die	De	S	Di	Di	De	-	Si	-	-	-	-	Se
	Catastrophes	-	Die	-	-	Die	De	-	-	Die	-	-	Si	-	-	-	-
	Mineral Extraction	-	-	Si	-	-	Se	-	Die	Di	-	-	Ni	-	-	-	Se
	Fishing/Poaching	-	-	Si	-	-	-	-	Di	-	-	-	De	-	-	-	-
	Gas/Oil Extraction	-	-	-	-	Se	De	-	Si	Di	Se	-	Si	-	Se	-	-
	An Indian Freedom of Religion Act	-	Ni	-	-	-	-	-	Si	Di	-	-	-	Se	-	-	-
	Logging	-	De	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EXOTIC ENCROACHMENT	Plants	Ni	Die	Die	-	Si	Di	-	Di	De	De	Di	Ni	Ne	Nie	Die	-
	Noise: motor vehicle	-	Ne	-	-	-	-	-	Di	Di	Di	Si	-	-	-	Nie	Si
	aircraft	-	Ne	-	-	-	De	-	Si	Ne	-	Di	Se	De	-	Nie	Se
	industrial	-	Ne	-	-	-	-	-	Se	-	-	-	-	-	-	-	-
	visitor	-	Ne	-	-	-	-	-	-	Ne	-	-	-	-	-	Si	-
	Animals	-	Die	Si	-	De	-	-	Die	Di	De	Se	Nie	Ne	-	Di	Si
	Seismic Blasting	-	De	-	-	-	Ne	-	Ne	Ne	De	Se	Ne	-	-	-	Ne
	Unnatural Weather	-	Se	-	-	-	-	-	Se	-	-	-	-	-	-	-	-
	Unnatural Fire	-	Die	Ni	-	De	-	-	-	Di	De	-	-	Ne	-	-	-
	Other	-	-	-	-	-	-	-	-	-	-	-	-	Ne	-	-	-
VISITOR IMPACTS	Trampling	Di	Di	Ni	-	Ne	-	-	Ni	Ni	Ne	-	-	-	-	Si	Si
	Erosion	-	Di	Ni	-	Ne	Die	-	Ni	Ni	Ne	-	-	Ni	-	-	-
	ORV	-	-	Ni	-	De	Die	-	Ni	Ni	Se	Di	Ni	Se	Si	-	Si
	Wildlife Harassment	-	-	Si	-	-	-	-	-	-	-	Di	Si	Ne	-	-	-
	Campfires	Di	Di	Si	-	De	-	-	Si	Di	De	Di	-	Se	-	Di	Ni
	Habitat Destruction	-	-	-	-	-	-	-	Ni	Nie	-	-	Si	-	-	Di	-
	Subtle Influences	-	-	-	-	Di	-	-	-	Ni	-	-	-	-	-	-	-
	Other	-	Si	-	-	Ne	-	-	-	Ni	Ne	-	-	-	-	Ni	-
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PARK OPERATIONS	Roads/Utility Corrid	Se	-	Di	-	-	Die	-	-	Ni	-	De	Si	Ni	Ni	Ni	Si
	Facilities	-	-	Di	-	-	Di	-	-	-	-	-	Si	-	-	Di	-
	Political Pressures	Se	-	-	-	Se	Di	-	De	-	-	-	-	-	-	-	-
	Suppression of Fire	-	-	Nie	-	Ni	-	Nie	-	-	Di	Ni	Si	-	-	Si	-
	Trails	-	-	Di	-	Ni	-	-	-	Ni	-	-	-	Ne	-	Di	-
	Employee Unawareness	-	-	Si	-	Si	-	Di	Si	-	-	-	-	Si	-	-	-
	Research	-	-	-	-	Si	-	-	-	Di	Si	-	-	-	-	-	-
	Misuse of Biocides	-	-	-	-	-	-	-	-	-	-	-	Se	-	-	-	-
	Other	-	-	-	-	-	-	De	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Key to letter codes:

Threat level

D = adequately documented

N = known threat, needs documentation

S = suspected threat, needs documentation

Threat source

i = threat internal

e = threat external to park boundary

to fulfilling the selection criteria, provide exceptional opportunities for coordinating scientific activities regionally, nationally, and internationally.

Assuming funding is made available, we propose to begin implementing long-term monitoring in four parks, including three Biosphere Reserves, in FY 1982, and add 12 more in FY 1983. In the southwest, the two desert Biosphere Reserves, Organ Pipe Cactus National Monument and Big Bend National Park, are presently being considered as project sites in FY 1982 and 1983, respectively. As presently proposed, the Organ Pipe Cactus project includes an intensive faunal inventory and water resource utilization study, with particular emphasis on endangered species; climatological and meteorological monitoring; development of in-park residential quarters for researchers; geohydrological studies of the groundwater system supplying Quitobaquito Springs; and the development and operation of a groundwater monitoring network. The Big Bend project, now in early formulation, may contain studies of the ecological effects of exotic species, livestock grazing, regional energy development, visitor activities, and other human influences.

A comprehensive multidisciplinary science program assessment will be initiated a year before project implementation in each of the "special initiative" parks. The assessment for Organ Pipe Cactus N.M. will begin later this year. The purpose of the assessment is to develop a basic reference on scientific data bases and science activities in the park and the immediate region. It will enable independent review by the scientific community of past, ongoing, and planned science activities; assist in developing monitoring and research programs; help identify opportunities for regional coordination; and, most significantly, provide a basic reference for research and resource management professionals working in the park. The assessments will be patterned on a prototype now being completed for the Great Smoky Mountains National Park Biosphere Reserve, which is involving more than 60 scientists in its preparation. This assessment has greatly expanded our knowledge of information available, often in unpublished form and in obscure locations, about park ecosystems. It is our present intention to develop assessments for all NPS-administered Biosphere Reserves within the next several years, expanding the initiative to include other areas if funds are available.

In addition to the special initiative to support long-term ecological monitoring, the bureau has recently completed a systematic evaluation of significant resource problems in every park, and has developed a bureauwide prioritization of scientific studies and management projects needed to address these problems. In the southwest, problems identified for priority attention include air and water quality impairment and cactus poaching at Big Bend; hydrological, air quality, and interrelated ecological impacts

of uranium mining and energy development near Chaco Canyon; the ecological impacts of 40 years of fire suppression at Chiricahua; control of feral burros at Death Valley; declines in endangered species and competition between the desert bighorn and exotics at Guadalupe Mountains; and potential impacts of regional groundwater withdrawals and vegetation impacts from exotic animals, particularly the oryx, at White Sands. Although funding for these projects is not yet assured, the Administration has expressed its strong support of measures to reverse deterioration in park resources and facilities, particularly in the major natural area parks. A proposed amendment to the Land and Water Conservation Fund Act would allow funds traditionally available only for land acquisition to be used for rehabilitation and maintenance. If approved by the Congress, the proposal would make available \$105 million in FY 1982 for improving the condition of the parks, of which the National Park Service is recommending the allocation of \$5 million to support research and resource management projects to address significant resource problems. Under the NPS recommendation, \$1 million would be allocated to support long-term ecological monitoring in old-line natural area parks, principally Biosphere Reserves, with a strong emphasis on the development and testing of promising methodologies for detecting and assessing natural and anthropogenic changes in natural ecosystems. Regardless of the outcome of congressional deliberations on the amendment, a substantial increase in support for scientific research in the National Park System seems reasonably assured in the years immediately ahead.

As we expand our research activities to meet the complex challenges of conserving natural ecosystems in a climate of unprecedented social, economic, and ecological changes, we remain mindful of the benefits to be gained through domestic and international cooperation in building scientific and management capabilities, standardizing methodologies, developing data management systems, and implementing programs to perpetuate and enhance the productivity of the biosphere. The stepwise development of carefully conceived cooperative projects which further the objectives of many institutions provides opportunities for cost effective solutions to major management problems not achievable by sectorial approaches. In this context, the cooperative management program for the endangered Kemp's ridley turtle (*Lepidochelys kempii*) initiated in 1978 between Mexico and the United States serves as a model for successful interinstitutional and inter-governmental cooperation in achieving the commonly shared objective of establishing a protected nesting site and reversing the population decline of this important marine reptile.

We anticipate that the rapid pace of development in the southwest will provide the driving force for obtaining the scientific data required to conserve and enhance the productivity of the dryland ecosystems of the region for the benefit of human society. The National Park Service

looks forward to exploring ways to improve the use of National Park System areas in achieving this regional objective through cooperative scientific, management, and educational programs.

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Status of the Mexican Wolf and Grizzly Bear in Northern Mexico¹

Jose C. Treviño F.²

Abstract.--The actual range of the Mexican wolf is less than 10% of its historical range in Mexico. During the 50's and 60's its population was drastically reduced by the use of 1080 and other predator control methods. Since 1974, it has been protected by Mexican laws and from 1976 by the Americans. It is listed in both countries as endangered, and its total population is estimated at less than 20 animals, in southwest and north Durango, central and northwest Chihuahua.

A captive breeding program has been developed by mutual agreement between Direccion General de la Fauna Silvestre and U.S. Fish and Wildlife Service, who form the Joint Mexico/United States Committee for Wildlife Conservation. Seven males and one female are in the program; no breeding success has been observed since the program started in 1977.

The grizzly bear has been considered extinct by some authors in northern Mexico. However, surveys in central Chihuahua (Sierra del Nido), habitat evaluation, and signs found, show positive features of grizzlies in the area. Also, a bear observed in April 1980 had some grizzly features. Reports from local ranchers said that "grizzlies still inhabited Sierra del Nido." Trapping will continue until signs previously found can be clearly identified.

Research and protection are needed for both species. The captive wolf breeding program should continue until success is reached.

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HISTORICAL INFORMATION AND WORK DONE

Mexican Wolf

Historical records on wolves in Mexico go back as far as the Spanish Colony in 1579 (Barlow 1944, quoted by Leopold 1965). The wolf's range and total population were unknown and ignored, due to the fact that game and livestock were plentiful enough to satisfy food needs for these first settlers. First reports started when world beef and wool demand increased, around 1914 (Gish).

The wolf's historic range reported by Young and Goldman (1944, cited by McBride 1980 and Nunley 1977) was from southern Arizona (Fort Bowie), southwestern New Mexico (Hatch), and western Texas (Fort Davis) to the Valley of Mexico.

Introduction of livestock to the range previously occupied by wolves increased the prey for them, and so serious were these depredations that control was exercised in every area occupied by wolves (Leopold 1965). First predator control efforts for wolves were done in the States by the Bureau of Biological Survey in 1915, and were supported by the Territorial Bounty Act passed in 1893. Gish, in his reports of historical records of the Gray Wolf in the Territory of Arizona, said that "most of the wolves were exterminated between 1915 and 1934 with the help of the federal government."

Nunley (1977) reports that most of the wolves were exterminated between 1915 and 1948 in New Mexico. Scudday reported that control efforts started in Texas in 1890, and continued to 1945; by 1915 most of the wolves were killed. Wolves were exterminated in central Mexico in the

late 1800's and only surviving in the Sierra Madre Occidental in Sonora, Chihuahua, Durango, Zacatecas, and Coahuila (Leopold 1965).

Predator control efforts include traps, rifle, den hunting, and poison (strychnine, 1080, and cyanide). The use of 1080 began in the States in the 40's, and was adopted in Mexico in the 50's. It has been the most effective method to control wolves, being odorless and without taste. Now, its use is forbidden in both countries.

By the 50's, the southwestern U.S. was considered free from resident wolves (Nunley 1977). However, in Mexico wolves were still abundant in the Sierra Madre (Leopold 1965).

Typical wolf habitat includes pine-oak (*Pinus* spp. *Quercus* spp.) communities; they prefer open grasslands with scattered oaks for feeding as well as elevation. Elevation ranges from 1,800 to 2,200 m, where it is cool in summer with an 18° C average temperature (McBride 1980).

Wolf densities were estimated by McBride in 1977-78. He estimated a total of 50: 15 in southwest Durango, 6 in north and west Durango, 2 east of Casas Grandes, and 6 in Sierra del Nido (the last two areas are in Chihuahua). Surveys conducted this past year in resident wolf areas, traveling routes, and denning sites, plus reports from ranchers who removed some wolves in Chihuahua, indicate the total population could now be less than 20 animals.

In spite of the efforts to protect the wolf, it is being killed by ranchers because of attack on cattle. It is known that the 1080, produced in Japan, is imported via Los Angeles and ranchers keep offering rewards for their capture.

Several programs concerning protection and conservation are sponsored by the Joint Mexico/United States Committee for Wildlife Conservation. A captive breeding program was started in 1977, with eight animals (seven males and one female), believed to have a direct blood relationship. To date, no breeding success has been observed, and it looks like only one male is not related to the others.

Grizzly Bear

Grizzlies were first reported in Mexico by James O'Pattie in 1820 in the mountains of northwest Baja California. Its historical distribution in Mexico was northwest Baja California Norte, northeast Sonora, Chihuahua, and north central Coahuila (Leopold 1965).

Some researchers have considered the grizzly bear extinct in northern Mexico and southern U.S. However, bibliographies and reports by people in Chihuahua have awakened an interest in the possibility of their existence.

In 1977, the Joint Committee previously cited began surveys to determine whether grizzlies still inhabit northern Mexico. An area called

Sierra del Nido, in the State of Chihuahua, was considered the best place to find grizzlies in Mexico. Surveys and habitat evaluations carried out in cooperation with the Border Grizzly Project indicate that it is a good grizzly habitat (Lyndon and Thier 1969).

The type of vegetational community is pine-oak, with pine dominant at higher elevations and several species of oak in the lower parts. High densities of manzanita (*Arctostaphylos pungens*) are found on west slopes, and in deep canyons with high humidity where cottonwoods (*Populus* spp.) are present. Elevation ranges from 1,670 to 3,000 m in the highest points. Topography is rough in the east (more than 50% slope) and smooth in the west (less than 25%).

Biologists from the Vertebrate Museum of Berkeley, California, reported tracks and signs of grizzlies in Sierra del Nido from 1957 to 1960. At the symposium on the Chihuahuan Desert in Alpine, Texas in 1972, Dr. Bernardo Villa reported poisoned grizzlies as a result of predator control efforts with 1080, done in the winters of 1961-1964 and 1973-1974 in Sierra del Nido (BGP 1977).

In 1968, Dr. Carl Koford surveyed some canyons in the area, and concluded that "there was a small chance that grizzlies still inhabited the area." Also, Stephen Johnson from Defenders of Wildlife, went to Sierra del Nido in 1975, but couldn't find any positive signs of grizzlies. Leopold (1965) reported that "the last grizzlies legally taken in Sierra del Nido were in 1955 and 1957 by Isaias Garcia."

Several surveys done in the area by the author found positive signs of grizzlies: tracks that measured 24.1 cm (9 1/2 in.) long by 12.7 cm (5 in.) wide; forehands, 15.3 cm (6 in.) by 14 cm (5 1/2 in.); measures of 1.9 cm (3/4 in.) to 5.8 cm (2 in.) of claw marks from toe pads; teeth marks in small trees at heights of 1.70 m (67 in.), and mud and hair in rubbing trees at heights of 2.04 m (80 1/2 in.); 50-kg rocks moved in trails and embedded deep in the soil; and hair collected with colors from goldish brown to white 9 cm (3 1/2 in.) long. Traps were set for 51 trap-days in 1979, and 16 trap-days in 1980 without success. Every time the traps were checked, the bears moved to other areas; perhaps noise and odors disturbed them. The areas were isolated from human and livestock activities.

During April 1980, a big bear was sighted at an approximate distance of 300 m. It appeared to have some grizzly features--head, ears, and claws (which shine at that distance). Up to now, it hasn't been clearly identified as grizzly or black bear.

CONCLUSIONS

Both species are in a critical situation with respect to density and range.

The Mexican wolf captive breeding program should continue. Wolves for the program should be provided, first, from those that cause economic damage before they are killed by cattlemen. A similar program should start in a fenced wolf-proof area, where the wolves should be free, in order to understand their critical habitat, type of food throughout the year, behavior, reproduction, natality, and mortality, so in the future it can survive free as in historic times.

The bear studies should continue to determine whether grizzlies still survive in Mexico. If so, protection and management programs should be improved to reestablish it in its historic range.

For both species, research, time, and economic support are needed to save and protect them from extinction.

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Baja California: Its Characteristics and its Natural Resources¹

Eng. Fernando Diego Diez²

Abstract.--This work gives a summary of the physical characteristics and the natural resources of the State of Northern Baja California, presenting the measures taken by the Federal and State Government in order to protect its renewable natural resources and its environment.

INTRODUCTION

The protection of renewable natural resources and of the environment in general has been established worldwide as an immediate need, since population growth and the technological development, among other factors, have endangered the natural ecologic balance which is indispensable for the survival of every living thing.

The state of Baja California is not threatened because its vegetation and wildlife are determined by terrestrial ecologic conditions: its beaches and the oceanographic characteristics of its seas.

GENERAL ASPECTS OF THE STATE

Location

To the northeast of Mexico lies the state of Baja California which is a part of the Baja California Peninsula. It occupies an area of 70,113 KM² which represents 3.75% of the total national area.

Orography

There are two mountain systems:

- (A) One of them begins at the north, and is known as Sierra de Juarez; it crosses the state and penetrates Baja California south where it is called Sierra de Calmalli.
- (B) The other one runs parallel to Sierra de Juarez, and is known as Cucapas; there is between them a sandy depression known as Laguna Salada.

¹Paper presented at "A Workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States." Rio Rico, Arizona, April, 20-24, 1981.

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Water

The main water resource is the Colorado River. It flows out of the United States, for 96 km in Mexico, and then into the Gulf of California.

The main aquifers are located in filled zones which originate in the rocks of the high river basin, and are fed mainly by the scarce rainfalls.

Climate

In general terms, there are two climatic zones:

- (A) In the valley of Mexicali, the climate is arid and desertic, with extreme and prolonged summers. Temperatures sometimes rise to 47° C; average annual rainfall is 76 mm.
- (B) In the coast area, the climate is of the mediterranean type, with scarce rains, except in the central and the southern part of the State where the climate is dry and arid, with limited rainfall throughout the year. Ensenada collects 331 mm in 32 rainy days, and its average temperature is 16.6° C.

NATURAL RESOURCES

Shores

The State has 1,129 km of shore which represents 11.6% of the country's shores. There are 13 bays and 55 islands, 19 in the Pacific and 36 in the Gulf of California.

Vegetation

Vegetation such as mesquite, cacti, and agave are predominant in the desert and semi-

desert zones. There are also two forest zones which have been designated as National Parks: the Sierra de Juarez and San Pedro Mártir. Together they have an area of 85,432 ha and contain a variety of pines such as pinyon, ponderosa, and Colorado, as well as poplar, manzanitas, and chamizo.

Wildlife

The mule deer, coyote, mountain lion, bobcat, fox, badger, and bighorn sheep are important species found in the State, but they are in danger of extinction.

The javelina, mountain goat, pronghorn antelope, and the mountain quail have become extinct.

Among its wildlife we also find a variety of birds such as pheasant, quail, geese, and white-winged dove, a species exclusive to Baja California. Compared to previous years, there has been a decrease in migratory birds such as geese, ducks, and cranes.

Marine Life

The shores of our State contain an abundant variety of marine life. Principal edible species are abalone, shrimp, lobster, tuna, mackerel, oysters, and turtle. There also exist the elephant seal and the sea lion.

The gray whale reproduces in the Guerrero Negro Bay and in Ojo de Liebre Bay.

The damage caused by man was the main reason for the deterioration of our forests. The State of Baja California, in conjunction with other branches of the Federal Government, has decreed a series of measures to protect the renewable natural resources and the environment. Some of these are:

- (1) The establishment of open and closed hunting seasons for all species of

wildlife in the State.

- (2) Permanent vigilance to prevent illegal hunting during the closed season.
- (3) In order to protect bighorn sheep and mule deer, a limit will be established for hunters of those species.
- (4) In the same manner, closed season will be established for the marine wildlife.
- (5) For forest protection, the city of Tecate established a Society for Fire Prevention and for the Conservation of Natural Resources. This society is made up of a President who is the Governor of the State, an Executive member who is the Municipal President of Tecate, a Treasurer, a group for Technical Counsel formed by all Government branches involved with forestry, the Fire Department, the Customs Officials, and the Military.

As a matter of information, in the period between October 1978 and September 1979, 25,000 ha were burned in the State of Baja California. From October 1979 to September 1980, 8,860 ha were burned. This decrease in the number of hectares burned is the result of the permanent vigilance and the activities of the Society.

Faced with the undeniable reality of worldwide ecological damage caused by immoderation and extermination of the Animal Kingdom, it is most important to take the necessary steps to protect species and to achieve thus the balance that Nature requires. Man must become the watchman and protector of this equilibrium; it is therefore necessary to establish closed seasons for hunting to protect wildlife and enhance its development. It is also important to intensify vigilance in the forests, and to educate the forest visitors. The use of chemicals must be regulated so that their use will not harm the ecosystems. These, among other measures, are necessary to prevent the deterioration of the environment, on whose equilibrium our survival depends.

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Research Strategies of the New Mexico Department of Game and Fish¹

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Wain Evans²

Abstract.--Annual expenditures for research-type activities is about \$500,000. Priority research consideration given rare, threatened or endangered species which have reasonable potential for recovery. However, greatest expenditures are on game and furbearing species. Current emphasis in research is in building environmental-management models on mule deer, elk and reservoir fisheries.

INTRODUCTION

The New Mexico Department of Game and Fish currently expends \$500,000 per year on various activities which may be loosely defined as fishery and wildlife research. Research priorities and objectives are determined by appropriate line divisions in the Department. Depending upon available funding and personnel, data collections may be conducted by Department personnel or contracted with one of several universities in the State. Due to growing complexity of research, the Department relies increasingly on the involvement of experts and specialists, through contractual arrangements, in all phases, particularly in organization and analysis of data.

In addition to its own research, the Department is a frequent participant at various levels in cooperative programs with the U. S. Forest Service and the Bureau of Land Management. In some cases the Department acts as a pass-through agency for federal funding to a subcontractor, and in other cases the Department may contract itself to do the work, depending on availability of qualified personnel.

In recent years, the Department has been retreating from the "scatter gun" approach to research that, unless consciously suppressed, results from the complex of funding sources and interests involved. The present philosophy is to concentrate research efforts along parallel lines of investigation and maximize compatibility among the various projects.

¹Paper presented at "A Workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States." Rio Rico, Arizona, April 20-24, 1981.

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PRIORITIES

Selection of research programs by the Department are influenced by many factors including biological considerations, funding availability, funding sources, and professional and public interest. In general, our first priority of consideration is given those wild species which are rare, threatened or endangered, but where management has a potential of significantly improving their status. Our continuing work on desert bighorn, Socorro isopod and Gila top minnow are examples of first priority projects.

Although threatened species with recovery potential receive first consideration, most research monies are expended on investigations involving game or furbearing animals and their environments. Objectives of these programs are strictly management oriented. Our ongoing elk and deer research are examples of this category as are the fishery studies being conducted under contract to New Mexico State University.

Emphasis on game and furbearing species is largely dictated by our federal funding under the Pittman-Robertson and Dingell-Johnson Acts which specify, in general terms, how monies developed under these acts will be spent. Further, we must keep in mind that at present it is the relatively few game species that provide the economic base, through license sales, for funding state management of all wildlife. Until laws are changed so that nonconsumptive users pay their full share, success of the State's wildlife management program is dependent upon those few species people are willing to pay to hunt, fish or trap. Consequently, emphasis in research placed on this group is not only deserved, it is a matter of practical necessity, even if it

means that some nongame species will be ignored.

EMPHASIS IN RESEARCH

In 1974 the Department began an inhouse review of its past and present research and the contribution of research to wildlife management in New Mexico. In general, we found little interaction between the two activities. Research regarded itself in the context of a "swat team," responding to real or imagined crisis with a particular species on a specific area. Problems in management, however, are more fundamental. Given available resources, managers could not develop an adequate data base on most species anywhere in the State for defining management objectives, prescribing management actions, or identifying management alternatives.

The crux of the problem was insufficient methodologies, given existing manpower and fiscal resources, for systematic and continuous monitoring of wildlife populations on a statewide basis and inadequate methodologies to employ such information in developing management objectives and alternatives. Attacking the crux of the problem has since become the overall objective of our research.

We are certainly not the first wildlife agency to conclude that inability to monitor and predict population parameters as the major impediment to sound scientific management. These problems are universally recognized and continue to be the subject of investigative research in many states. However, our solution is unique in that we have abandoned the idea that managers will ever be able to continuously monitor populations through any direct monitoring system on a statewide scale. Direct methodologies, if developed, will be too labor intensive to meet the manager's requirements.

Our line of attack is from the standpoint of the ecosystem which produced the population. If we understand the statistical relationship between a population's parameters and pertinent environmental parameters, quantification of environmental parameters enables quantification of the population parameters using appropriate mathematical conversion equations. The attraction of this approach is that many environmental parameters are already quantified and continuously monitored by several governmental agencies, and satellite technology will greatly increase the detail and extent of environmental monitoring in the future. All these data are available to the wildlife manager and can be assembled for analysis on any geographic area at relatively little cost in time, manpower and fiscal resources. In this context, the role of research is to mathematically define the necessary correlative relationships between environment and population.

At present, our research is most advanced on mule deer and the first generation environment-

management model has been developed. The tactical and technological problems associated with this type of research have been largely solved for terrestrial ecosystems and are being researched in aquatic systems. Data gathering on elk is entering its third year and entering its second year on reservoir fisheries. In the near future, we will be incorporating antelope and bobcats into the system.

Opportunities for cooperation with Mexico or other agencies in this environmentally based research appears considerable so long as the environments of interest can be quantitatively defined in terms of pertinent parameters. In terrestrial ecosystems these parameters include climate, elevation, weather, hunting pressures, gross habitat designations, grazing history class of livestock, road access, etc. Environmental data accompanied by population parameters, regardless of where or when the data was collected, can simply be incorporated into the model building process and add strength to the system.

In its simplest form, this concept views a study population as a plotted data point on a graph where the dependent variable is the numerical value of the population's parameter and the independent variable is an index value of the population's environment. In this context, model building is the formulation of "best fit" regression lines connecting data points developed from several study populations scattered across the environmental spectrum. Management is the process of deciding the desired value of the population's parameter and altering the population's environment to produce it.

In practice, of course, the process is far more complex than plotting points on a two dimensional graph. Actual models are multidimensional, interactive and expensive to develop. However, once operational, the system will provide month-to-month population monitoring capability by continuous updating of environmental data, and will provide testing capabilities for management alternatives through simulation experiments. Further, models are designed with numerous windows for checking predictabilities against actual field data collected by direct measurement (i.e., sex ratios, age structure, weights, etc.) during hunting or other planned activities.

Realistically, we anticipate our environment-management research to continue evolving into the foreseeable future as more data becomes available and our experience grows and expands. However, the first operational generation of models for mule deer should be ready within three years, followed shortly by incorporation of elk and antelope. Eventually, we plan to extend the system to all major species in the State.

The Wildlife Research Goals and Strategies of the Arizona Game and Fish Department¹

Ronald H. Smith²

Abstract.--The research goals and specific objectives of the Arizona Game and Fish Department are outlined. A set of recommendations are presented for federal-state cooperation on problems of habitat management for the benefit of wildlife.

INTRODUCTION

Wildlife research conducted by the Arizona Game and Fish Department is centered on species that are taken by sport hunters. Limited funds and their source precludes any shift in emphasis away from game species in the near future.

Most research of our Department is conducted by a staff of 6 biologists within the Research Branch. Funding comes from the Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act), a federal grant-in-aid program. Monies from a federal excise tax on sporting arms and ammunition are apportioned to the states on a 75 federal:25 state matching basis.

There is one fisheries study being conducted within the Research Branch on the Colorado River at Lee's Ferry. It is an attempt to evaluate the effect of fluctuating river levels on the important rainbow trout fishery in the river below Glen Canyon Dam. This work is funded under the Dingle-Johnson Act, a congressional act which is companion to the one which supports wildlife research.

ASSIGNMENT OF PRIORITIES

Our Department does not have a well defined system for assigning research priorities. In the past, research objectives have been formulated and proposed by research personnel based on what the individual researcher felt was the greatest need. They were then reviewed and approved or rejected by the management branches. The acceptance of the proposal in some cases was related more to the manner in which the proposal was written and presented than to an evaluation of

what was the greatest need. Other research jobs were conducted to handle short term problems in management.

More recently, however, research priorities have come to be based on problems identified in our species management strategic plans. The big game strategic plan was completed and made available to the public within the past few weeks. It identifies about 120 specific research needs in the management of Arizona's 10 big game species. The lack of an organized research plan leaves us susceptible to the acceptance of short term (brush fire) projects with short term goals. The short term approach may solve area problems and even, incidentally, provide information of broader application. This approach, however, does not generally provide the information needed for the long term management of game species.

DESCRIPTION OF CURRENT RESEARCH

The Department's major game research project currently addresses 15 separate job objectives although some are closely related. These objectives are organized broadly as follows:

Techniques

New technology is constantly needed for either management or research. The Department is currently financially supporting a project to develop a prototype optical sensor for censusing ungulates on winter ranges. Utah State University is doing the basic research and development under a cooperative project with Arizona, Oregon and Utah.

Population Dynamics

Most of our program falls under this broad category of jobs, and includes studies of vital statistics of game populations such as population size, sex and age structure, survival and mortality, and how such factors as hunting, predation, and disease affect these statistics.

¹Paper presented at workshop on "Wildlife and Range Research Needs in Northern Mexico and Southwestern United States", Rio Rico, April 20-24, 1981.

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The Department's studies of the black bear are typical of this category and are probably the best example of the kinds of effort most likely to benefit the long term welfare of a hunted species. Bears are being studied in two major vegetative types - chaparral and ponderosa pine. We are learning much about mortality and survival, population density and structure, habitat use, home areas and movements, reproductive success, denning dates and duration, and their importance to hunters. The biologist assigned to this work (Al LeCount) has become a regionally-recognized specialist on almost every aspect of black bear biology and management.

It is sometimes charged that wildlife research is not problem-oriented but rather allows the individual researcher to find some niche in which he can work and attempt to satisfy his career goals. If the Department's black bear studies fall within the range of this criticism, the results of these studies show the fallacy of some of this criticism. These studies have produced a wealth of well substantiated information that will contribute to improved bear management and to the preservation of critical habitat.

The mule deer on the Kaibab Plateau is the subject of another important study. Over the years this deer herd has yielded a greater harvest of deer than any other management unit in the state. Some of the research on the Kaibab began in response to the decline of that herd from 1969 through 1976. It was designed as a short term, problem-oriented study to find causes for the deer decline. Despite its short term goals, this study and companion studies on the Kaibab are providing a sizable body of information on deer migrations, seasonal habitat use, diets, and mortality factors. This deer herd has experienced dramatic changes in population size over the years and the degree to which sex and age classes within that herd are harvested may be an extremely important factor in these fluctuations. Our research effort should allow us to do a better job of measuring deer herd characteristics and of understanding how these characteristics are related to the climate, habitat, and human factors that affect them.

Habitat studies

Undoubtedly the most important way in which resource managers will affect the long term welfare of wildlife species is through habitat management. We have sometimes been tempted to dismiss or underrate the importance of habitat change or loss because short term and dramatic undulations in wildlife populations may be caused by other factors such as predation, climate, or over-hunting. In the absence of long term studies, it is impossible to measure or observe the effects of habitat change since they are masked by these more proximal factors.

Our Department's program has tended to be more concerned with these proximal factors for several reasons. We have statutory authority to

directly regulate wildlife populations through sport hunting, depredation control, and relocation. We do not have the same authority to manage rangelands and forests. Our management of game animals through the manipulation of seasons and hunting pressure must be responsive to short term factors such as climate.

Our studies of the pronghorn antelope and the coyote on Anderson Mesa best illustrate the focus of most of our studies. Four years of research demonstrated that the coyote is the most important proximal cause of antelope fawn mortality on the Mesa. The second phase of this research is cost-benefit evaluation of a time-specific coyote reduction program. The severe winter of 1968-69 reduced this population to about 150 animals. In the early 1950's, Unit 5B had supported almost 2000 antelope. At the present low population level, coyotes have been found to be taking about 90 percent of the fawns born each year. The lack of adequate fawning cover is believed to be the ultimate factor that predisposes fawns to this heavy loss. It is a factor over which we have no control. It is, nevertheless, an appropriate subject for long term study.

Although the emphasis of our research is on problems relating to population dynamics, we are conducting several studies of habitat.

On the North Kaibab deer summer range we are attempting to determine site factors most favored by deer. Site selection is being inferred from the density of pellet groups on those sites. More direct measurements of habitat use and preference are also being made year-round from the locations of radio-collared deer.

A very similar approach is also being used to determine habitat selection by black bears in chaparral and mixed conifer areas. Bears are being radio-located from aircraft throughout the year. The habitat characteristics of location sites are being described and related to the frequency of bear sightings within site categories.

RECOMMENDATIONS FOR COOPERATIVE STUDY

Given the fact that most of the wildlife habitat in Arizona is under the jurisdiction of federal agencies, habitat studies by the Department must of necessity be cooperative.

In view of the increasing pressures on renewable and non-renewable resources and the current trends towards a production-oriented economy, both state and federal agencies are going to have to work together more closely to assure that wildlife values are given adequate consideration in resource management plans. In order to get that consideration, more baseline data is needed on the habitat requirements and preferences of wildlife. With better baseline data we can construct better models to predict the likely impact of various environmental pressures.

These pressures specifically identified within our own big game strategic plan are livestock grazing, timber harvest, fire suppression, and recreation. Listed below are some broad hypotheses that reflect the major concerns of our Department for the welfare of game species on federal lands.

Livestock Grazing

Overgrazing by cattle has seriously degraded the capacity of our rangelands to support elk, mule deer, whitetailed deer, antelope, and big-horn sheep. We need to know more about the habitat requirements of these species and the degree of competition with livestock for forage, water and space. This is an excellent area for long term interagency cooperative study.

Timber Harvest

Timber and watershed management practices, particularly in mixed conifer habitats, are removing excessive overstory to the potential degradation of elk cover requirements. There is some concern among our wildlife managers and specialists that timber managers would, if possible, gradually convert the mixed conifer type to a ponderosa pine monoculture. Because the habitat requirements of elk in northern Arizona are not well understood, the effects of intensive selective thinning and shelterwood systems in the mixed conifer type on elk cannot be predicted and should be investigated.

Fire Control

The successful control of fire on forests and rangelands during the last 25 years has had important long term effects of forest and rangeland ecosystems. Again, the effects on these changes on vegetation and on game populations are subtle on a year-to-year basis and are masked by the more dramatic things that affect ungulate populations. These effects are nonetheless worthy of long term cooperative study on a large scale or regional basis.

Other Impacts

Wildlife habitats are being continually eroded by highway building, housing development, energy transmission corridors, mining, and recreational developments. One of the most pressing needs is for a unified system for determining the extent of our major wildlife habitats and the changes that are occurring on these areas. This is a promising subject for state-federal or international cooperative research. A geographically-based information storage and retrieval system is needed which can be accessed and run under interagency cooperative agreement. The availability of sequential aircraft and satellite resource data makes this technically feasible. I would recommend that a pilot regional cooperative project be initiated to develop and test such a system.

Cooperative Work with Migrating Upland Game Birds and Waterfowl

Whitewing doves, mourning doves, bandtailed pigeons, and many species of waterfowl migrate to the western coast of Mexico after being hunted in the United States. Recovery rates of banded birds which are shot both in the United States and Mexico suggest that some birds, particularly whitewing doves, are being overharvested in the United States. Much new information on hunting mortality could be obtained if it were possible to band Mexican resident whitewings. The relative mortality rates of Mexican-raised birds and United States birds could be compared. It is also possible that Mexican nesting birds migrate to the United States and contribute to the harvest here. These and other important questions could be answered if a large number of birds could be banded in Mexico.

The same kinds of information are needed for bandtailed pigeons.

Wildlife specialists in the United States are anxious to contribute to a cooperative banding project.

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**Observations on the Distribution, Abundance, and
Productivity of the Osprey in the Ojo de Liebre—
Guerrero Negro Lagoon, B.C.S., Mexico¹**

Aradit¹ Castellanos-Vera²

Abstract.--Ninety three osprey nests were found in the Ojo de Liebre-Guerrero Negro Lagoon, B.C.S., Mexico in 1980. Seventy nine of them were on three small islands (islotes): 40 on Islote Conchas, 34 on Islote Piedra, and 5 on Zacatosa; there were 14 nests established on man-made structures outside of the islands. On the first and last islands the nests were on the ground; on Islote Piedra most of them were on Adam's trees, rocks, and on the ground. The nests on the towers were 4-6 meters high; some over water, some on the seashore, and two inland. Seventy one nests were occupied by nesting pairs, 46 of them were active, and of these only 18 were successful, producing 24 fledged birds. The observed productivity index was 0.52 chick per pair, which is below the estimated average (0.95 to 1.30 chicks per nesting pair) for migratory osprey in North America according to Henny and Wright (1969). The productivity of nests built on man-made structures was higher than that of nests built on the ground. Historic evidence indicates an increase in population from 27 pairs in 1946 (Kenyon) to 71 in 1980. Production is affected by predators such as gulls and coyotes, as well as by high tides. Pesticides apparently do not have a significant biologic impact (Spitzer et al. 1977). This paper discusses these matters and proposes some methods for the conservation of the local population.

INTRODUCTION

In 1964 Ames and Mersereau reported a decrease in the osprey population along the Connecticut River due to DDT; since then various studies have been undertaken to evaluate the osprey situation in North America and in other areas of the world.

During the second half of the sixties, this bird was included in the Red Book of "Endangered Wildlife and Rare Fishes of the USA," and it was cataloged as "undetermined status;" in Canada it was considered "endangered" (Henny 1977). In some areas of North America the species has shown a decrease in population and productivity, thinner eggshells, etc.; changes linked to the effects of

pesticides and contaminants such as DDT, Dieldrin, and PCBs on their metabolism.

Distribution in North America

In North America the osprey is found mainly in the Atlantic Coast, the Great Lakes region, the west of the United States, and the south of Florida and Mexico. The osprey from the latter two areas are not migratory and are smaller in size; nevertheless, they are not considered different subspecies. They also differ from the northern population which has a reproductive period from May to July; the osprey in Mexico do not have this characteristic (which makes their supervision more complex) for one can find pairs in different reproductive stages from December to June. On the other hand, these non-migratory birds have been studied to a lesser degree, and there are still unknown aspects of their reproductive biology and ecologic requirements.

Along the western coast of the Baja California Peninsula the osprey nests are concentrated in the following areas: Natividad Island of San Ignacio, and the Magdalena lacunal complex.

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This work, developed in the Ojo de Liebre-Guerrero Negro Lagoon, and whose objectives were to determine the distribution, magnitude, and productivity of the local osprey population, is part of the efforts of the Direccion General de Fauna Silvestre for the conservation of the wildlife of the area, especially of the birds and mammals included in the agreements for protection existing between Mexico and the United States. The osprey is one of the species which both nations are committed to protect.

AREA OF STUDY

The lacunal complex Ojo de Liebre-Guerrero Negro is in the mid-western part of the Baja California Peninsula, open to the great Sebastian Vizcaino Bay.

The Guerrero Negro lagoon at the extreme north, on parallel 28°N, is rectangular in shape, with dimensions of 5.5 X 9 miles. The Ojo de Liebre lagoon, with 156 mi², is separated from the Guerrero Negro lagoon by a narrow strip of land which is covered by water during high tides. Both are shallow, with channels and currents of considerable speed (4-5 knots). Their margins are formed by shifting dunes, saline marshes, nitrous plains, and evaporation holes. The surrounding vegetation is halophytic, no more than 30 cm high. Within the Ojo de Liebre lagoon are five small islands: Conchas, Piedra, Zacatosa, Broza, and Choya. There are some man-made structures scattered in the lagoon to point out the channels or shallow waters.

MATERIALS AND METHOD

Initially in March we began to locate the nests in the different areas of the lagoons, using a fiberglass boat with a 40 hp outboard motor. The nests inland were checked using an all-terrain vehicle. All nests were marked with progressive numbers (in wood); they were visited six times up until the end of May when the chicks left their nests. A control board was used to monitor data such as date, condition of the nest (empty, reconstruction, etc.), number of eggs, number of live chicks, estimated age of chicks, etc. Since the work was begun in March and the reproductive period began in December, some nests which might have been occupied and even active at the beginning of the season and which later were abandoned, were not included in this study.

RESULTS

A total of 93 nests were located in the lagoons and the surrounding areas; of these, 71 (76.3%) were occupied by nesting pairs in the reproductive season. Seventy nine of the nests (84.9%) were found on three of the small islands: 40 on Islote Conchas (43.0%), 34 on Islote Piedra (36.5%), and 5 on Islote Zacatosa (5.3%); the other two islands were not inspected; on one of them, (Islote Broza) there are 4 nests--3 old ones and 1 occupied according to the 1981 count. Of

Table 1.--Distribution and abundance of nests in the study area.

	Areas	Number of nests	% of total
Natural sites	Is. Conchas	40	43.0
	Is. Piedra	34	36.5
	Is. Zacatosa	5	5.3
Artificial structures	Canal		
	Chaparrito	10	
	Punto Viego	1	
	Parallel 28	1	15
	Zona Mareas	2	

the remaining 14 nests (15%) which were built on man-made structures, 10 were on towers over the water, 2 on the seashore, and 2 inland.

Ratio of Occupied and Active Nests, and Observed Productivity

Of the 70 occupied nests, one was not considered because it was not accessible; it was possible to inspect it only through binoculars.

Of the 70 occupied nests (with known results) 46 (65.7%) were active, that is, they contained eggs; 34 (73% of the active) contained chicks; however, only 18 nests (39.1% of the active) were successful, producing 24 fledged birds. The productivity index observed was 0.52 chick per nesting pair. In this work the index is based only on the number of active nests (nests with eggs), following the recommendation of Henny and Van Velzen (1972).

DISCUSSION

Interpretation of the Productivity Index Observed in the Historic Context of the Area.

By counting occupied nests, Kenyon (1946) determined the nesting pairs in the Ojo de Liebre lagoon to be 27; 16 in Islote Conchas, 10 on another small island, and 1 on Islote Nido; on Islote Piedra he reported only 7 old nests, abandoned, and concluded that this was due to coyotes. In 1957, 25 nests were estimated for Islote Conchas; in 1970 there were 22 active nests, and 20 (17 with eggs) in 1971; that year the estimated population for the lagoon was 30 pairs (Jehl 1977). Reyes Osorio (1976, unpublished) reported 26 active nests in Islote Conchas and 23 on Islote Piedra, some of them under reconstruction. That year various nests with eggs were attacked by coyotes. On March 3, 1977 (Reyes Osorio) 21 pairs were occupying nests in Islote Piedra, 1 nest with eggs. That same year, Henny and Anderson reported 41 pairs for the lagoon complex (27 pairs on 3 islands, and 14 on man-made structures), and estimated 50.1 nesting pairs for the lagoon. From 1946 to 1980 man-made structures have increased in number; the towers in the Chaparrito Channel were built in 1967, nine of which hold occupied nests; the three towers with nests on the Guerrero lagoon were built around 1957,

Table 2.--Number of occupied and active nests and productivity index.

Area	Occupied nests	Nests with eggs	Nests with chicks	Successful nests	Fledged birds	Productivity index
Is. Conchas	37	24	20	9	12	0.50
Is. Piedra	17	7	2	0	0	0
Is. Zacatosa	4	3	2	1	1	
Torres	12	11	10	8	11	10
Totals	70	46	34	18	24	0.52

while the Monument of Parallel 28 was built in 1974 along with the Transpeninsular Highway.

We obtained accurate data about productivity in the area for 1976 only from Table 3 (Reyes Osorio 1976, unpublished).

Following the criterion adopted for this work, the productivity observed in 1976 from Islote Conchas would be 0.61 chick per nesting pair, which is slightly greater than that observed in 1980 for the same area (0.50 chick per pair).

Based on the preceding information we estimate that the osprey population of the lagoon complex Ojo de Liebre-Guerrero Negro has grown within and even beyond the required levels to maintain its stability, so that there has been an increase in the number of nesting pairs there from 1946 to date. During that 34-year period the population grew from 27 to 71 nesting pairs, the number of nests on Islote Conchas increased, Islote Piedra was occupied again, and new nesting places were selected (man-made towers).

Factors That Affect Productivity

Ospreys usually utilize the same nest year after year, reconstructing it each season, so that the nest can grow in size considerably. The building sites vary according to the general conditions of the areas where they live; near lakes surrounded by forests, nests are built on trees; man-made structures (towers, lighthouses, posts,

etc.) are occupied if no natural sites are available; nests are built also on shrubs, small objects, or directly on the ground. In some areas, for example on Islote Cedros, B.C., nests are built on seaside cliffs.

The Vizcaino Desert extends around the lagoon complex, dominated by halophytic thickets 30 cm high; there are no natural nesting sites such as trees or cliffs; consequently, the small islands are favored and, since they contain no land predators, the ospreys build their nests on the ground.

Utilization of Nesting Sites in the Area of Study

Ojo de Liebre Lagoon

On Islote Conchas, the 40 nests are practically on the ground; some are nothing more than hollows cushioned with eelgrass. Objects brought in by the tide (wood, drums, etc.) are sometimes utilized for support. The island lacks land predators, and its vegetative cover is limited to a small area. Other aquatic bird species, such as cormorants, terns, and the western gull, nest here.

On Islote Piedra, most nests are built on small shrubs and Adam's trees; others are on galloping cactus, rocks, and on the ground. During low tide the island is accessible to coyotes.

On Islote Zacatosa, the five nests are directly on the ground. The island floods at high tide.

In Chaparriot Channel, the nests are located on towers over 3 m high which mark the borders of this deep channel. There are 10 nests.

Guerrero Negro Lagoon

Two nests are on towers in high-tide zones; one nest is inland on the wall of a demolished house.

At Parallel 28⁰N, a nest was built on a Transpeninsular Highway sign, 5 1/2 m above the road.

The productivity index observed in the nests on Islote Conchas is lower than that of the nests built on towers; on this island we observed (as reported by Reyes Osorio in 1976) that the western

Table 3.--Number of nests, eggs, and birds produced in Islote Conchas in 1976.

Number of nests		Number of eggs	Number of nests		Chicks produced
3	with	1	14	with	0
7	"	2	8	"	1
15	"	3	4	"	2
1	"	4			
26		66	26		16

Table 4.--Ratio, nesting sites, and productivity.

Area	Is. Conchas	Zacatosa	Piedra	Chaparrito	Punto Viejo	Par. 28 ^o
Nesting site	Ground	Ground	Small shrubs	4 m above sea level	Approx. 4 m above sea level	45 m above sea level
Adverse factors	Gulls	High tide	Coyote	None evident	None evident	None evident
Productivity index	0.5 chick per nest	1 chick	0	1.25 chicks per nest	0	1 chick

Productivity index less than 0.50.

Productivity - 1.0 chick/nest.

gull (*Larus occidentalis*) which starts reproducing in March, destroys the osprey eggs, attacks its chicks, and snatches their food from the young; it also chases the adult ospreys to force them to release their catch. We have observed these birds attacking osprey chicks, trying to peck their heads or trying to remove them from their nests to devour them. On Islote Piedra there are many nests, but very few are occupied, much less active. Kenyon (1946) and Reyes Osorio (1976) report preying activity by coyotes; in 1980 various nests produced eggs and chicks on the island, but none produced fledged birds. On Islote Zacatosa

all nests but one were flooded by high tides. The nests built on towers had a higher productivity index than those of other areas; those nests are free from the activity of land predators, of high tides, and from attacks by gulls. The efficiency of nesting is higher, and a greater number of chicks is obtained.

There is not much evidence of the impact of pesticides or other contaminants in the area of study. Spitzer et al. (1977) in their analysis of the DDE, PCB, and mercury concentrations in osprey eggs collected in different parts of

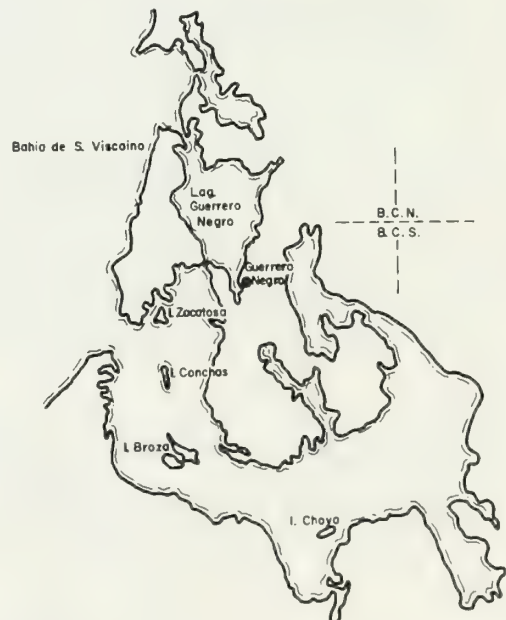


Figure 1.--Lagoon Complex-Ojo de Liebre and Guerrero Negro.

North America (including eggs from Isla Benitos, Lake Ojo de Liebre and the Gulf of California) found moderately high levels of DDE and PCB in the eggs of Isla Benitos, B.C., and lower levels--compared to those obtained in eggs of a more northern region--in the eggs from the Gulf of California. In general, the contaminant levels were among the lowest in North America, and the thickness of the eggshells apparently was normal.

We have determined that the factors which affect the bird production in the lagoon complex mostly are predators (gulls and coyotes), and high tides. The islands are occasionally visited by local fishermen, but in general, human disturbance is low in the area since there is not much maritime traffic, and the islands are not visited by tourists.

RECOMMENDATIONS

We consider that various steps must be taken beginning in 1981 in order to conserve the local osprey population in the lagoon complex Ojo de Liebre-Guerrero Negro, B.C.S., Mexico.

1. Continue studies of the reproductive activity, especially observe the yearly productivity and define the factors which affect it. The studies should be done in depth, including aspects such as behavior, feeding habits, ecologic requirements, etc.
2. Extend the geographic area for the studies; include Islote de Cedros and the San Ignacio lagoon in order to have a broader base for comparison.
3. Begin construction of towers for nesting on the small islands.
4. Develop a program for public information and ask the residents of the community, especially the fishermen, for their cooperation in the task of preserving this species.

DEFINITIONS

Nest or nesting site--Structure built by the bird for its reproductive activities.

Occupied nest--Nest where at least one of the following phenomena was observed:

- a. Nest being reconstructed, presence of recently transported materials.
- b. Eggs in the nest.
- c. Chicks.

Occupied nests are divided into:

- a. Active nest--nest containing eggs or chicks.
- b. Inactive nest--nest which contained ospreys but no eggs were laid (reconstruction).

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Current Status of the Mule Deer on Tiburon Island, Sonora¹

Sandalio Reyes Osorio²

Abstract.--During October and November of 1980 we studied the ecology of the mule deer population on Tiburon Island. In a sampling area of 130 km² we censused 110 animals, estimating a population density of 0.8 animals per km², and a total population of 869 animals. The sex proportion is 48.17% females, and 29.09% males. Of the total females in a fertile stage, only 57.89% were raising young; 86.36% of these females had produced one young, and 13.63% had produced two, the average being 1.1 young per female. Actually, the fertility index is 65.78%. The rate of population growth in 1980 was 46.26%. Currently there is a tendency towards population stability and there are good prospects for the future.

INTRODUCTION

Of all the species of wildlife that inhabit Tiburon Island, the mule deer (Odocoileus hemionus sheldoni) is the largest native mammal. Its importance as a huntable species in Sonora has led biologists from the General Administration of Wildlife in Mexico to study its biology and ecology on Tiburon Island.

The biologic studies are geared towards knowledge about the reproductive cycle, the biotic potential, and the nutritional diet; the ecologic studies deal with the dynamics and numbers of the population, the supporting capacity of the habitat, and the spatial arrangement of the population.

The information obtained through these studies establishes the technical basis for a broad study in the continental area; one which will assert the rational utilization and conservation of the species. That is, a fair management.

BACKGROUND

In the presidential decree of March 15, 1963, Tiburon Island was declared by the Mexican

Government a "Natural Reserve Zone and Wildlife Shelter." Since then, the island has been managed by a State Protective Agency sponsored by the Office of Forestry and Wildlife of the Department of Agriculture until 1970. During this period the Agency was devoted exclusively to protection and vigilance, and it did not conduct any biologic research of the ecosystem.

The Agency was dissolved in 1970, and the General Administration of Wildlife from the Department of Agriculture took over the management, creating the Experimental Station and Wildlife Studies which currently manages the island.

With the creation of the Experimental Station, the General Administration of Wildlife named various biologists to be responsible for wildlife studies, succeeding each other consecutively during the decade of 1970-1980.

During that decade, the biologists conducted systematic studies on the trend of the mule deer population in Tiburon Island (Quiñones 1970-71; Salgado 1972-74; Rodriguez 1975-76; and Muñoz 1977).

The author conducted his studies during the last two years, 1979 and 1980, and will continue this project in 1981. This work is on the trend of the mule deer population in Tiburon Island as it was observed in October and November of 1980.

SAMPLE CENSUS

The population was estimated through 26 samplings in 17 locations on the island, from north to south. The sampling scale was standardized at 5 km², consisting of 5 km length and 1 km width,

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observing the animals directly through binoculars. The total surface sampled was 130 km², equivalent to 11.95% of the total inhabitable surface of the island. The minimum reasonable index of total sampling surface is 10%.

POPULATION STRUCTURE AND ABUNDANCE

On the sampled area of 130 km² we observed 110 animals and estimated a population density of 0.8 animals per km² (Table 1). In the ecology of animal population, the population density is synonymous to the term "census index." Considering the 0.8 density and the inhabitable surface of 1,087.2 km² on Tiburon Island, we estimated a total population of 869 animals in 1980.

The total surface of the island is 1,208 km², and 10% is not habitable due to certain topographic factors which will be discussed later.

The population observed in the census sampling was structured into four categories: adult female 34.54%; young female 13.63%; adult male 29.09%; and young under 1 year 22.72% (Table 2).

During this study, the young were at the most, six months old, born in July and August. The sex proportion is 48.17% female and 29.09% male. Females are 19% more abundant than males. Comparatively, the sex proportion observed in 1979 was 38.77% female and 28.57% male (Table 3).

Table 1.--Population/density of the mule deer by sampled locations on Tiburon Island in 1980.

Location	Sampling km ²	Number animals	Density ann/km ²
Tecomate	10	0	0
Jamoncillo	5	0	0
Pozo Cayetano	10	4	0.4
Corro Picudo	5	8	1.6
Caracol	10	5	0.5
Tinaja Blanca	5	9	1.8
San Miguel	15	25	1.5
El Carrizo	5	4	0.8
Cerro del Kumaro	10	12	1.2
Cerro Sto. Domingo	5	10	2.0
El Chalate	10	13	1.3
San Juan	5	2	0.4
Valle Espanoles	5	6	1.2
El Sapo	5	2	0.4
El Perro	5	10	2.0
Las Cruces	10	0	0
El Sausal	10	0	0
Total	130	110	15.1
Average density			0.8

Table 2.--Structure of the mule deer population on Tiburon Island, 1980.

Category structures	No. animals	%	Population estimate
Adult females	38	34.54	300.41
Young females	15	13.63	118.54
Adult males	32	29.09	253.01
Young under 1 year	25	22.72	197.60
Total	110	99.98	869.56

BIOTIC POTENTIAL

Of the total female population observed, we counted 38 adult animals considered sexually mature for reproduction. From the ecologic point of view, of these females in a fertile stage, only 22 (57.89%) were raising their young, and the other 16 (42.10%) had none. Of the females with young, 86.36% had one young, and 13.63% had two; the average estimated was 1.1 young per female. Considering the total population of mature females (38), and the births observed (25), the fertility index in 1980 was estimated to be 65.78%.

POPULATION GROWTH

There was a big increase in the population of mule deer on Tiburon Island during 1980 compared to 1979. Births and migration were responsible for the population growth. Mortality was low. The percent index calculated for the three factors are as follows:

$$\begin{aligned}\text{Natality index} &= 22.72\% (197.60) \\ \text{Mortality index} &= 3.74\% (32.61) \\ \text{Migration index} &= 27.72\% (237.30)\end{aligned}$$

The data were obtained from the analysis of the censuses conducted in October and November, considering that by the end of the year most of the biologic and ecologic phenomena had occurred and could be summarized. Thus the rate of population growth was estimated according to the following formula:

$$\begin{aligned}\text{Rate of population change} &= \text{Natality index} - \\ &\quad \text{Mortality index} \\ &\quad + \text{Net Migration} \\ &\quad \text{index.} \\ &= 22.72 - 3.74 + 27.28 \\ &= 46.26\%\end{aligned}$$

The growth of the mule deer population in Tiburon Island in 1980 was at a rate of 46.26%.

POPULATION DYNAMICS

During the decade of 1970-1980, some very drastic changes have been observed in the mule deer population on Tiburon Island.

The curve of population growth shows that the highest growth occurred in 1970 and 1971. During the first year of study (1970), the density was 1.1 and the population was estimated at 1,196 animals; in 1971 the population reached a density of 1.5, and a total population of 1,631 animals. After this year, the population decreased considerably and reached a density of 0.4 (434 animals) in 1979, the lowest population recorded in the decade (Table 4).

It is reasonable to say that the equilibrium point of the population on the island is at a density of 1.1 or 1,196 animals, where the supporting capacity of the habitat is at its maximum. A higher density of 1.5 (1,631 animals in 1971) is beyond the supporting capacity of the habitat and there was overpopulation. Environmental resistance factors had a drastic influence on the biotic potential, and the population not only returned to its equilibrium point, but was critically reduced. In nine years it still has not returned to its level of equilibrium (Graph 1).

However, in 1980 the population is recovering at a population change rate of 46.26%.

SPATIAL DISTRIBUTION OF THE POPULATION

The spatial distribution of the population is the way the animals are distributed over the habitable area. The distribution of the mule deer on Tiburon Island is crowded and follows the characteristics of the habitable area.

During the last two years of study, it has been observed that the inhabitable space on Tiburon Island is discontinuous--that is, the environment is heterogeneous. On the one hand are the topographic factors; on the other, the climatic conditions which vary from one end to the other. These factors and conditions affect survival, and the animal's behavior is not constant.

Topographic factors influence the altitudinal distribution, and animals will inhabit up to

Table 3.--Comparative structure of mule deer population on Tiburon Island 1979-1980.

Category structures	1979-22 Samples		1980-26 Samples	
	animals	%	animals	%
Adult females	16	32.65	38	34.54
Young females	3	6.12	15	13.63
Adult males	12	24.48	32	29.09
Young males	2	4.08	-	-
Young under 1 year	12	24.48	25	22.72
Not identified	4	8.16	-	-
Total	49	99.97	110	99.98

Table 4.--Population statistics for mule deer, Tiburon Island, 1970-1980.

Year	D/km ²	Population
1970	1.1	1,196
1971	1.5	1,631
1972	0.7	761
1973	-	-
1974	0.5	630
1975	1.0	1,087
1976	0.9	978
1977	0.6	652
1978	-	-
1979	0.4	434
1980	0.8	869

400 m levels, occasionally up to 500 m, and rarely 600 m. The earlier biologists estimated that elevations over 400 m comprise 10% of the total area of the island, which is not habitable for deer. If the total surface of the island is 1,202 km² and 120.8 are over 400 m high, then only 1,087.2 km² is the habitable space for mule deer.

The climatic conditions in the habitable space vary irregularly each year, but within limits compatible with survival. Then there are zones where conditions are best, and the animal concentration is higher; zones where conditions are average, and the number of animals is also average; and finally, zones with minimal conditions for survival, where the animal population is low or zero. These characteristics of the climatic conditions of the habitat determine the distribution of animals.

In the studies of 1980, the spatial distribution of the population was statistically quantified. In October and November, 17 locations were sampled: 3 in the north, 2 in the south, 8 in the center, and 4 between the center and the south (Map 1). The percentage distribution of the population was as follows:

CENTRAL AREA: CONDITIONS NEAR OPTIMUM 78.18%

Cerro Picudo	7.27%
Caracol	4.54%
Tinaja Blanca	8.18%
San Miguel	22.72%
Carrizo	3.63%
Kúmaro	10.90%
Santo Domingo	9.09%
Chalate	11.81%

AREA BETWEEN CENTER AND SOUTH: AVERAGE CONDITIONS 18.18%

San Juan	1.81%
Los Españoles	5.45%
El Sapo	1.81%
El Perro	9.09%

NORTH AND SOUTH AREA: MINIMAL CONDITIONS 3.63%

North:

Tecomate	0.00%
Jamoncillo	0.00%
Pozo Cayetano	3.63%

South:

Las Cruces	0.00%
El Sausal	0.00%

DISCUSSION AND RECOMMENDATIONS

Tiburón Island is a limited ecosystem that allows a satisfactory study of the biology and ecology of wild animals because the observation of the development of its populations can be controlled.

Ecology of mule deer has been studied very extensively, and its population dynamics has been observed for a decade. The curve of population growth during 10 years shows critical variation in the rate of population change. The highest population registered was in 1971, with a density of 1.5, and a peak of 1,631 animals. During this period, the biotic potential created an overpopulation and the supporting capacity of the habitat was exceeded. Then environmental resistance (famine, competition) acted drastically, affecting reproduction and individual survival in such a way that the population decreased considerably

the next year, with a density of 0.7; three years later (1974) it decreased to 0.5. This self-control phenomenon was very drastic and almost endangered the population.




The evidence of this phenomenon is very strong. In the years following 1974, biologists collected many antlered skulls, and they found many animal skeletons. Another extrinsic factor which contributed to the decrease in population was illegal hunting.

Currently the population is recovering with a density of 0.8, close to the density recorded in 1970 (1.1) when the first study was conducted.

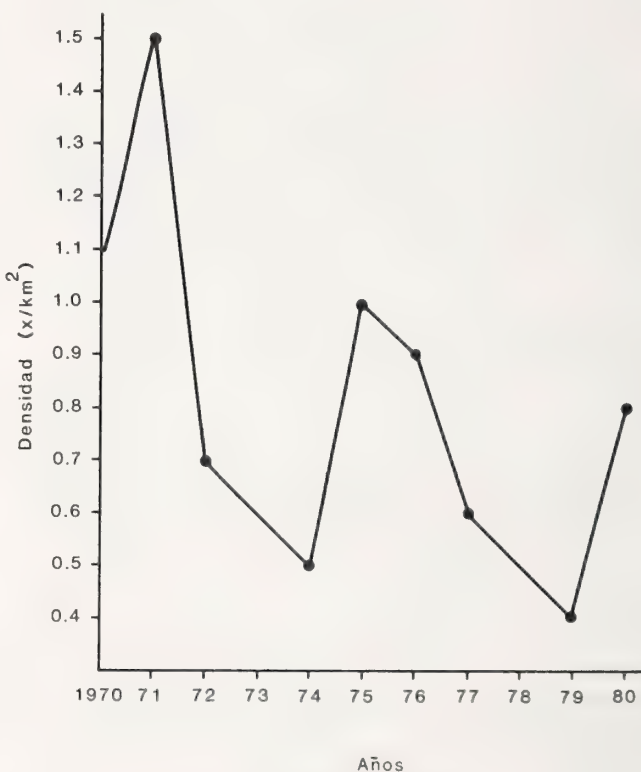
During the last two years we have established a vigilance plan around the island in order to protect the wildlife by avoiding the human activity that could harm the environment. Camping for fishermen has also been prohibited along the shores, for that, too, had some influence on the deer population.

On Tiburón Island the mule deer is the only native species of interest to hunters, but it would be risky to hunt it because of its low population. It is important that the island maintain its role as a Reserve Zone and as an Experimental Station for the scientific studies of flora and wildlife.



	Near optimum conditions	78.18%
	Average conditions	18.18%
	Minimal conditions	3.63%

Map 1.--Zones of space distribution for mule deer observed through October-November on Tiburón Island, 1980.



Graph 1.--Curve of population growth for mule deer, Tiburón Island, 1970-1980. 1.1 probable equilibrium level, 1.5 overpopulation, 0.5 population deficiency.

Moderator's Comments: Technology Transfer and Research Needs¹

Sanford D. Schemnitz²

A key to worthwhile research efforts in the Southwest and northern Mexico is to avoid repetitive and low priority efforts. Often much time and manpower is wasted by repeating work done previously by others. The first step in any quality research effort is a thorough review of existing literature and information. A comprehensive and detailed literature review is time consuming and expensive but nevertheless is essential and valuable.

Wildlife literature is diffuse and scattered. Moore (1980) is an excellent starting place to locate various wildlife literature. Computer searches often will expedite a literature search. The Fish and Wildlife Reference Service at Denver, Colorado, is an excellent source of unpublished Pittman-Robertson Federal Aid in Wildlife Restoration project reports and wildlife theses. Compilations of literature on wildlife and habitats of southwestern United States have been prepared by Patton and Ffolliott (1975), U. S. Forest Service (1975), Schemnitz et al. (1978), Bigelow et al. (1980), and Schemnitz (1981). Publications by personnel of the Rocky Mountain Forest and Range Experiment Station at Ft. Collins, Colorado, Arizona Game and Fish Department, Phoenix, and New Mexico Department of Game and Fish, Santa Fe provide much valuable and pertinent information. The Bureau of Land Management has published a series of bibliographies on raptors, endangered wildlife, and birds (e.g., Trimble 1975). Other publications on western wildlife of major significance include nongame bird symposia and workshops by Smith (1975) and DeGraaf (1980) and riparian habitat by Johnson and Jones (1977). These publications are available upon request.

Researchers often have a tendency to work on so-called "hobby" projects of personal interest based on experience, college training, and personal inclination. Such efforts are often enjoyable and self-satisfying but frequently do not yield essential information basic to the welfare of our wildlife resources and needs of the public. A solution to this dilemma is long-

range planning and establishment of priorities. Planning focuses efforts on important and major problems. Establishing research priorities enables us to get the best return on our research investment.

One aspect of technological transfer in which wildlife workers in general are woefully lacking and inadequate is communicating research results to the general public. We rightfully have been accused of talking to ourselves. Our writings too frequently are confusing and unintelligible often due to too much scientific jargon. Gilbert (1971) stated that our job was not complete when we published our research results in a referred journal. Popular writing for the general public should be written for an eighth grade level of education. Public understanding means public support and increased financial support for worthwhile research and management programs.

Other examples of technological transfer we might employ include encouragement of attendance of our Mexican colleagues at our annual New Mexico-Arizona meeting of The Wildlife Society during the first weekend in February. We wildlifers need to communicate more effectively with non-wildlife-trained land managers such as foresters, range, and soil conservationists in order to make them more aware and appreciative of wildlife habitat needs. Many of these people are wary and "gunshy" of wildlife biologists. We need to establish a better rapport with these key people. A recent example of a successful effort of this type was a week long short course held in January, 1981 at New Mexico State University, Las Cruces on "Principles of Wildlife Habitat Management in the Pinyon-Juniper Ecosystem". Forty-seven land managers from 6 federal and state resource agencies and 3 Indian tribes attended with 20 instructors from various universities and state and federal agencies. A similar short course on Wildlife in the Desert Shrub and Desert Grassland Ecosystems is scheduled for January, 1982. We encourage attendance by Mexican wildlife biologists and foresters.

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We need to improve our delivery of papers at meetings and talks to general audiences. Our participation at communication workshops conducted by Prof. Gene Decker, Colorado State University, Ft. Collins would improve our use of visual aids and related skills.

The structure and organization of federal, state, and university research programs is

often complex. Preparation and distribution of directories of personnel with addresses, telephone numbers, brief description of research interests, and a list of current research projects would enhance communications and expedite technology transfer. Much valuable information and expertise frequently is stored in files amidst unpublished data, research proposals, progress reports, and unpublished manuscripts. Such personnel directories would encourage an interchange of ideas via phone calls and correspondence, possibly followed by personal visits.

I would be remiss if I did not mention the RUN WILD system, a storage and retrieval system for wildlife habitat information described by Patton (1979). RUN WILD contains information on inventory, species habitat information, and management. Another good source of management information is the "Southwest Habitater", a publication by the U. S. Forest Service, Albuquerque, New Mexico.

Meetings of research specialists (e.g. bighorn sheep, black bear, deer, elk, prairie grouse, pronghorn antelope, white-winged dove, and wild turkey, etc.) are particularly fruitful and allow exchange of technical information via presentation of papers and in-depth discussion. Endangered species recovery team meetings serve a similar purpose. Researchers and managers frequently come away from such meetings imbued with enthusiasm and new ideas derived from lively discussions and exchange of viewpoints with peers. Despite tight travel budgets, we should all strive to encourage attendance at these species oriented meetings whenever feasible.

With increased pressures on wildlife populations and encroachment on wildlife habitats, we must intensify our management efforts based on sound research results. Improved technology transfer between researchers, managers, and the general public will be the "secret to success" in perpetuating our wildlife resources.

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**Recommendations on Wildlife and Range Research
Needs in Northern Mexico and Southwestern
United States¹**

E. T. Bartlett²

Abstract.-- The intended purpose of this workshop is to recommend range and wildlife research needs, and methods to transfer results to users. The recommendations of the three work groups overlap because of overlaps in subject areas. Research in all three areas should consider the human element of resource use. Finally, Biosphere Reserves provide logical sites for cooperative research between Mexico and the United States.

The primary objective of this workshop has been to specify research needs concerning range and wildlife in northern Mexico and southwestern United States, and to identify areas of cooperation. These groups will address the following subject areas: (1) wildlife habitat management and improvement, (2) range management and improvement, and (3) strategies for technology transfer. The first two areas are traditional topics in natural resource management, while the third reflects a much needed effort, effectively disseminating research results to decision makers and policy bodies.

It is always difficult to divide a group into subgroups and a broad topic into subtopic areas. Such is the case with the three working groups. It must be expected that the reports will overlap, as members of each group are knowledgeable of the general topic area: range and wildlife research needs. In fact, it would be disappointing if the groups on range and wildlife only discussed traditional research of the two subject areas, as they both deal with the same geographic areas. In addition, the success of any research that is recommended by the two resource subject areas are dependent on the transfer of technology. Thus all three topics of concern are intertwined.

¹Paper presented at the workshop on Wildlife and Range Research Needs in Northern Mexico and Southwestern United States (Rio Rico, Arizona, April 20-24, 1981).

²E. T. Bartlett is the Chairman of the U.S. MAB Committee on the Ecology and Management of Grazing Land (MAB-3) and Associate Professor of Range Science, Colorado State University, Fort Collins, CO.

The Man and the Biosphere Program (MAB) recognizes the interdependence of components of the environment and the human population. Research under the MAB Program is designed to help provide the kind of information needed to solve practical problems of resource management. It also aims to fill the still significant gaps in our understanding of the structure and functioning of ecosystems and of the impact of different types of human intervention. Until now, a great amount of research on the natural environment and resources has not been relevant to practical management problems. Often the focus has been too sectoral and results have not been applicable to other ecological or socio-cultural circumstances. In co-sponsoring this workshop, MAB has attempted to focus on the transdisciplinary nature of range and wildlife problems in the arid and semi-arid ecosystems of northern Mexico and southwestern United States.

Wildlife and domestic herbivores utilize rangelands of both countries and both help provide for human needs. The U.S. MAB Committee on the Ecology and Management of Grazing Lands (MAB-3) is concerned with improving man's partnership with rangelands. This committee, as all MAB committees, is vitally concerned not only with the impact of man on the environment, but also the repercussions of environmental modifications on man. The primary objective of US MAB-3 is to realize the production potential for each grazing area through sustained-yield management systems that are compatible with other human values. Three sub-objectives are:

1. To study the production capability of grazing lands, considering site characteristics, management opportunities, and present cultural practices.
2. To assess the animal production potential for each area and, where that potential

is not being reached, to assess the kind or kinds of animals needed to reach that potential.

3. To develop methods of technology transfer that will insure that the results of objectives (1) and (2) are transferred to the cultures of the peoples inhabiting grazing lands. This goal requires that management techniques be compatible with the cultural characteristics of the areas.

The working groups on wildlife habitat and range management have addressed the first two sub-objectives while considering the cultural constraints and characteristics of the two countries. There has been much discussion in the past about the productive potential of rangeland and forests. All of us can remember references and experiences that emphasize the fact that much of our land is producing far below potential, however, information is needed which will allow a definition of a site's potential which is essential for planning the best possible use of land and water resources to realize maximum sustained-yield.

Coincident with the need to assess potential of rangelands in terms of vegetation production, there is a need to assess animal production potential. If the long-term goal of managing rangelands is to optimize the production of animal products (meat, milk, fiber, hides, etc.) on a sustained-yield basis, it is as important to appraise the efficiencies with which different classes of grazing animals convert plant material as it is to determine those plant species which represent maximum forage production for a given site.

Technology transfer, the topic of the third working group, is the controlling factor; without it, any successful research resulting from the recommendations of the first two groups will

be of little value. If the scientific community is to have more than a negligible influence on man's impact on rangelands and his ability to manage these lands to gain maximum long-term productivity, then it is imperative that the development of new management strategies be carried out with a thorough understanding of the socio-cultural practices of the peoples who will ultimately be affected. This can only be accomplished if a two-way exchange of information and mutual respect is developed between the scientific research community on the one hand and the ranchers, herders, and decision makers on the other.

Finally, I would like to address Biosphere Reserves that have been discussed. The objectives of establishing Biosphere Reserves are:

1. to conserve for present and future use, the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends;
2. to provide areas for ecological and environmental research including, particularly, baseline studies, both within and adjacent to such reserves, such research to be consistent with objective "1", above; and
3. to provide facilities for education and training.

As is apparent, the second and third objectives relate closely to the purpose and scope of this workshop. Already such reserves have been used to conduct similar research in Mexico and the United States. I strongly suggest that those areas can be used as sites for research that is recommended by the working groups.

Working Group Reports ✓

WILDLIFE HABITAT

The multiple problems of managing wildlife cannot be addressed without considering habitat. The first obvious signs of degradation of wildlife habitat may be a reduction in numbers of individuals, or even the complete loss of some species. Thus, our recommendations move from the most apparent problem, (1) the loss of wildlife, through (2) the degradation and loss of habitat, to the most complex problem, (3) the socio-economic evaluation of areas as wildlife habitat.

Problem I: Imminent Loss Of Species

Species endemic to the Southwestern United States and Northern Mexico are subject to serious population losses due to overharvest or loss of habitat. It is important to identify those groups of animals which are most seriously threatened. We suggest that investigation begin with those species found both in Mexico and the United States, but study selection will be based on regional priorities. The following groups should have highest priority: rare cats, upland migratory birds, pronghorn antelope, raptors.

Some wildlife species have disappeared from historically occupied habitats in the Southwestern United States and Northern Mexico. Conditions may favor their re-establishment in historic ranges. Identification of those species which appear to be capable of restoration is important. Candidate species may be successfully maintained or reintroduced after restoration and rehabilitation of potential habitats.

Problem II: Immediate Loss Of Habitat

As mentioned in the Introduction, the most important group of factors regulating wildlife populations in Northern Mexico and the Southwestern United States includes the changes, alterations, and losses of important habitat conditions. An approach is suggested to modify and control these changes by assembling a data base for development of habitat management guidelines through a three-phase research program.

Phase 1 would be to identify essential habitats, determine factors affecting them, and develop research programs to provide data for management guidelines. In this arid region, riparian areas are among the most essential habitats. Although they make up only a small proportion of the region, riparian habitats indicate water--hence, they are concentration areas for all desert life, including man and his

livestock. Riparian habitats are disappearing at an alarming rate because of mismanagement.

Phase 2 would be to determine the amount of habitat change that can be tolerated by wildlife species. This would involve several subphases. The first step would be to initiate a concurrent program to examine baseline data to determine habitat changes through time and to identify and correlate individual species with specific habitats. For example, we are aware that some perennial grasslands have changed to small tree or shrub-dominated habitats in the last 50 years. These changes have resulted in more favorable habitat conditions for some species (deer, javelina, Gambel quail, and some small birds) but has created unfavorable habitats for others (Sonoran pronghorn, masked bobwhite quail, scaled quail).

Our knowledge of reasons for habitat change and resultant population fluctuations is inadequate for development of population guidelines. Research should investigate reasons for change and identify species that are most sensitive to these changes (i.e., indicator species). With this information, it will be possible to manage habitats for specific responses, and to monitor effects of such management by monitoring population responses of sensitive wildlife species.

We should also carefully determine what habitat changes or losses can be tolerated as a result of other land uses. It would be unrealistic to expect livestock grazing, suburban development, or energy exploitation to stop for the singular purpose of improving wildlife habitat. Their impacts can be reduced or mitigated, however, if sufficient ecological information is included along with political, economic, and social considerations. For example, wildlife biologists are acutely aware of the impacts of overgrazing by livestock on wildlife habitats, but little or no attention has been directed at how livestock grazing could be manipulated to enhance or improve habitat.

Phase 3 would be to develop habitat management guidelines to insure that realistic wildlife habitat needs are met. This involves putting all information described above into functional, simplistic models that would give land managers the opportunity to develop alternative land use plans.

Problem III: Socio-Economic Evaluation Of Wildlife Habitat

Increased land uses relating to ranching, agriculture, urbanization, and tourism are competing

for wildlife habitat by reducing floral and faunal density and diversity. The resulting loss of wildlife is commonly interrelated with the loss of other resources, upsetting the "balance of nature" and in turn affecting associated socio-economic values.

We recommend that teams examine various wildlife factors and establish their economic values. Basic factors should include: hunting, fishing, use of wildlife for food, camping and hiking, nature observation, and aesthetics. Additional factors would include the importance of economic and social values of "non-use" that are external benefits/costs (such as scientific research, retention of germplasm) as well as passive or negative effects on agriculture and livestock. This information should be gathered and organized for most effective presentation to decision makers.

RANGE MANAGEMENT

The arid areas in Northern Mexico and the Southwestern United States share many range management problems and potentials. Projects outlined by this working group identify the need to utilize existing technology for management of resources, including the grazing animal, and to establish criteria for the potential application of rangeland improvements.

The group identified several specific opportunities where projects could be initiated. It strongly recommends that other locations and opportunities for action be identified, and that participants of this conference implement specific cooperative projects.

Problem I: Determine Criteria For Site Potential and Strategies For Range Improvement

Many rangelands in Southwestern United States and Northwestern Mexico have deteriorated as a result of past or present overgrazing. Some of these rangelands have greater potential for improvement than others. Potential productivity of deteriorated sites needs to be determined, and strategies to improve long-term production of these sites need to be developed.

Research Needs:

1. Determine the potential of range sites for forage production based on historical knowledge of vegetation use and controlled areas (Experiment Stations and Biosphere Reserves).
2. Determine history of deterioration, such as physical environment (lowering of water table, soil losses, prolonged drought), historical grazing practices, classes of livestock use, and fire suppression.
3. Based on findings from data available, develop strategies for improving deteriorated range sites and test. This would

give the land manager an array of alternatives from which to choose to improve long-term productivity.

4. Initiate these studies on the Pinacate and Organ Pipe Biosphere Reserves.

Problem II: Develop Grazing Management Strategies For Arid Environments

Grazing management strategies must be established that will maintain ranges in a condition suitable for sustained yield of animal products, consistent with preservation, improvement, and multiple use of range ecosystems. The number one priority in establishing such strategies is to determine the carrying capacity of range sites. Once this carrying capacity has been determined, political and economic processes should be implemented to enforce proper stocking rates. Year-to-year-climatic oscillations should be considered when setting stocking rates.

Grazing systems should be selected on the basis of phenology and physiological requirements of forage species found on the range sites in question. Grazing systems should be designed to encourage natural successional processes if these result in a more desirable forage supply. Grazing systems should also sustain the physiological health of forage species. Grazing strategies should also have the flexibility necessary to preserve, improve, and allow the multiple use of arid range ecosystems.

Research Needs

1. Identify criteria upon which the current carrying capacity of range sites may be based. These criteria must be measurable with a minimum investment of money and time.
2. Determine the physiological response of forage species to harvest (grazing) strategies.
3. Determine the impact of grazing systems on different range sites upon the diets, activities, and performance of animals.

Problem III: Range Improvement Research

Cooperative research activities aimed at increasing sustained yield of renewable resources through range improvement should be developed. Many ranges have deteriorated through past misuse as indicated by loss of desirable plant species, increase of undesirable plants, and reduced effectiveness of rainfall due to erosion or compaction of soils.

There is a need for range improvement where site conditions are favorable but where grazing management alone will not improve productivity in a reasonable time. Such research should be carried out with the realization that range improvements must be accompanied by better grazing management practices and by educational programs to insure that improvements are properly used and maintained.

Research Needs:

Some improvements, such as fencing or live-stock water development, are not site specific. However, the subjects listed below require testing in specific ecosystems (climate/soil/vegetation communities) no matter where they were developed.

1. Selection, improvement and establishment of adapted plant species.
2. Control of undesirable vegetation by burning, chemical control, biological control, and mechanical control.
3. Measures to improve on-site water use and reduce erosion (ripping, furrowing, contour dikes, water spreading).
4. Monitoring of impacts of range improvements on wildlife and non-market values.

TECHNOLOGY TRANSFER

The Working Group developed an extensive list of individual and cooperative efforts that could be explored to enhance technology transfer between Mexico and the United States in the management of renewable natural resources. Eight primary efforts are suggested to establish patterns and channels of cooperation. Group participants took responsibility for initiating action on each task:

1. A directory of organizations involved in research on, and management of, range and wildlife resources would help establish better communication between U.S. and Mexican professionals. Such a directory should

- include names of individuals, addresses, telephone numbers, and areas of expertise.
2. Development of a Mexican Forestry Information Network parallel with WESTFORNET in the western United States would not only benefit information retrieval in Mexico, but would also establish a network for technical information exchange between the two countries.
3. An exchange of computer software and programs would greatly reduce duplication of programming effort.
4. The RUNWILD system of classifying and retrieving wildlife habitat information could be expanded to include ecosystems in Mexico.
5. Cooperation in the development of standardized research and inventory methods would simplify and speed up information exchange.
6. Cooperative cartographic work in processing satellite imagery would make valuable resource trend data more rapidly available to land managers and planners.
7. Cooperative efforts between U.S. and Mexican communication specialists could lead to improved understanding of, and therefore support for, range and wildlife habitat management programs.
8. Cooperative research efforts developed under the auspices of the Man and the Biosphere (MAB) program would encourage the exchange of both scientists and knowledge between Mexico and the United States.

Additionally, the Range Management Working Group proposed the establishment of a special task force to focus specifically on communication of range management technology. The objectives of this task force would be to revitalize, improve, and/or develop channels of communication both from researcher to user, and from user to researcher.

245 Range Research and Resource Management in Southern Arizona¹

Alvin L. Medina²

Abstract.--Summarizes five field-day presentations given by various authorities on range research, resource management, and ranch management in southern Arizona. Emphasis is given to range research on the Santa Rita Experimental Range and resource management on the Coronado National Forest.

INTRODUCTION

A principal objective of range research is to provide useful information to help resource professionals solve management problems. Range research on the Santa Rita Experimental Range (SRER) has contributed a wealth of useful information about southwestern semidesert grasslands. The Forest Service has coupled such research findings with ingenuity to solve particular management problems.

This paper summarizes five oral presentations given during field trips to the Santa Rita Experimental Range and Coronado National Forest during the Workshop: (1) ranching and research--the role of the cooperators on SRER, (2) vegetation responses to climatic factors, livestock grazing, and mesquite control, (3) the Santa Rita Grazing System, (4) responses of yearling cattle and Lehmann lovegrass to grazing, and (5) the Hog Canyon management area. Additional information concerning specific studies is referenced.

RANCHING AND RESEARCH--THE ROLE OF THE LIVESTOCK COOPERATOR ON SANTA RITA EXPERIMENTAL RANGE (William A. McGibbon, Santa Rita Ranch)

The livestock cooperator on the SRER plays an important role in research activities. Without his complete cooperation, experiments and demonstrations would not be successful. The cooperator's five main areas of responsibility are to:

1. provide livestock for research purposes;
2. provide money for experiments;
3. assist in implementing livestock studies, including pasture rotations, weighing, sorting, and identification of livestock, record keeping, and reporting;
4. cooperate in planning and construction of improvements;
5. maintain range improvements in sound condition.

The cooperator integrates the SRER (520 head) operation with other grazing on the Coronado National Forest and private, private-leased, and State lands. This arrangement allows him the flexibility to meet research needs on SRER, when larger or smaller numbers of cattle are needed. The cooperator must continually strive to increase the efficiency of his operation, however, by implementing innovations and minimizing losses from thefts, vandalism, and so forth, while providing a wholesome, marketable, and desirable commodity. A profitable business is realized in this manner.

VEGETATION RESPONSE TO CLIMATIC FACTORS, LIVESTOCK GRAZING, AND MESQUITE CONTROL (S. Clark Martin, University of Arizona)

Changes in vegetation since 1957 on four pastures on the Santa Rita Experimental Range, as affected by climatic factors, cattle grazing, and the control of velvet mesquite, were studied by Cable and Martin (1975).

Production and utilization were measured annually from 1957 to 1966 at 20 locations in each of four pastures. Mesquite trees were killed between 1954 and 1957 by spraying the stem bases with diesel oil (Reynolds and Tschirley 1957). A followup treatment in 1960 killed remaining plants. Two changes in grazing management were begun at the start of the study: (1) the utilization objective was lowered to 40%, and (2) summer deferment (July to September) in alternate years was started.

¹Summary of field tour presentations and discussions on Santa Rita Experimental Range and Coronado National Forest, in conjunction with conference on "Wildlife and Range Research Needs in Northern Mexico and Southwestern United States." Rio Rico, Arizona, April 20-24, 1981.

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The major findings of the study are summarized below (Cable and Martin 1975):

1. Perennial grass production averaged between 352 and 524 lb/acre on the four pastures and had increased 168 lb/acre on mesquite-killed pastures.

2. The grass-producing effectiveness of a given amount of rainfall during a given summer depends on the amount of rainfall received the previous summer. Management decisions should be based on the idea it takes at least 2 years to recover from a 1-year drought.

3. Different levels of use significantly affected perennial grass production. Heavy use (52% to 59%) greatly restricted gains in production in wet years following a dry year. Gains were highest on areas with lowest use (21% to 28%) and decreased with each successively higher use level. Two or three favorable years were required for recovery of heavily used areas following a single dry year.

4. On optimum sites for grass growth and with no mesquite competition, annual grass production varied from zero where perennial grass production was 940 lb/acre to about 500 lb/acre where perennial grass production was 275 lb/acre (increasing 75 lb/acre for each decrease of 100 lb/acre in perennial grass production).

5. Maximum annual grass production was limited by the degree of mesquite cover. Production decreased about 50 lb/acre for each 10% increase in mesquite crown cover, and reached zero at about 40% mesquite crown cover.

6. Arizona cottontop (*Trichachne californica*) tolerated high levels of use (57%) with no noticeable adverse effects.

THE SANTA RITA GRAZING SYSTEM (S. Clark Martin, University of Arizona)

Since 1957, 21 grazing-rest schedules have been evaluated on the Santa Rita Experimental Range. Two of these appeared to be more detrimental than yearlong grazing, 15 were not clearly different, 5 appeared to be better, but only 1 of 5 was significantly superior to yearlong grazing (Martin 1978). The beneficial schedules were: Summer (July-October) rest 3 years out of 4, spring-summer (March-October) rest and yearlong rest 1 year in 3, yearlong rest 2 years out of 3, and spring-summer rest 2 years out of 3. Greatest

effects resulted from spring-summer (March-October) rest 2 years out of 3, the rest schedule incorporated in the Santa Rita Grazing System (Martin 1978).

The Santa Rita Grazing System is a one-herd, three-pasture, 3-year rotation adapted to the annual cycles of temperature, precipitation, and plant growth in southern Arizona, where plant growth during the frost-free period is limited to periods when soil moisture is available. Summer rains (July to September) produce 90% of the perennial grass herbage. Spring growth (February to May) produces only a little forage, but is critical for plants. The rest-grazing sequence is: rest 12 months (November-October), graze 4 months (November-February), rest 12 months (March-February), then graze 8 months (March-October) to complete the cycle (fig. 1). Each pasture is rested during both spring and summer growth periods 2 years out of 3. A full year of rest before each grazing period provides old herbage that helps protect new growth from grazing. This is especially important in the spring when cattle are hungry for nutritious green forage but growth is limited.

The Santa Rita schedule uses each year's forage crop. The first summer's crop is grazed during the winter (November-February) beginning immediately after the first 12-month rest period. The second summer's crop is grazed in the spring (March-June) following the second 12-month rest period. The third summer's crop is grazed as it grows (July-October), the period when animals make the bulk of their weight gain for the year (fig. 2).

Cattle are moved twice a year. One move, about November 1, is made at normal round-up time and the second move around March 1. Cattle are again gathered in May for branding. Labor costs associated with the extra move of March 1 are more than offset by having to work and service only one-third of the pastures.

Pastures in the Santa Rita system are stocked each year to furnish the same number of animal-months grazing as if they were grazed yearlong. Likewise, the utilization objective for perennial grasses in rotated pastures is 40%, the same as for pastures grazed yearlong. By stocking at

Pasture	Year One			Year Two			Year Three		
	Nov.-Feb. Winter	Mar.-June Spring	July-Oct. Summer	Nov.-Feb. Winter	Mar.-June Spring	July-Oct. Summer	Nov.-Feb. Winter	Mar.-June Spring	July-Oct. Summer
A				Graze					Graze
B		Graze					Graze		
C	Graze				Graze				

Figure 1--Three year sequence of grazing and rest for the three pastures in the Santa Rita Grazing System (Martin 1978).

triple the yearlong rate, the desired level of use is achieved in 4 months instead of 12.

We are currently comparing the Santa Rita grazing system (fig. 3) with yearlong grazing at three elevations on pastures that range from 308 to 2,185 ha in area and from 150 to 430 mm annual precipitation. The 12 pastures are stocked with a total of 419 cows, plus bulls during the breeding season. Results after two 3-year cycles (1978) were inconclusive. The third 3-year cycle of the study is to be completed in 1981.

One thing we have learned is that nature's influences are much stronger than ours. For example, we don't expect the three pastures in a rotation set to respond equally because the responses of forage plants in the pasture that is grazed during a season of severe drought, or one of exceptionally high rainfall, will not be the same as those of plants in the rested pastures. Rainfall differences between pastures can also outweigh grazing effects. Because the short-term impacts of climatic events are so much greater than the relatively small but persistent influences of management, it takes many years to adequately evaluate a grazing system.

RESPONSES OF YEARLING CATTLE AND LEHMANN LOVEGRASS TO GRAZING (Richard W. Rice, University of Arizona)

The principal objectives of this cooperative study on the ecology of Lehmann lovegrass (*Eragrostis lehmanniana*) are to: (1) determine the nutritive value and utilization of Lehmann lovegrass as affected by season and phenological stage of development, (2) determine the intake and utilization of Lehmann lovegrass by cattle grazing a relatively pure stand, (3) develop and test grazing strategies designed to provide maximum forage for grazing cattle while still maintaining productivity, (4) assess the response of Lehmann lovegrass to grazing intensity and season of use, and (5) design optimal grazing strategies for the integrated use of Lehmann

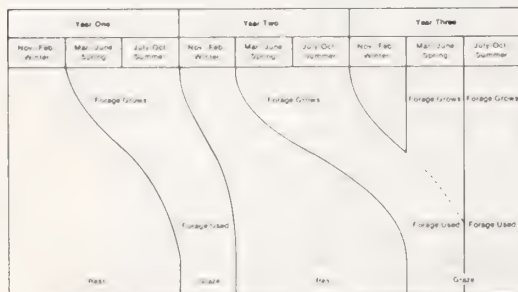


Figure 2.--Periods of forage growth and forage use for one pasture in the 3-pasture Santa Rita Grazing System. Similar sequences of forage growth and use for the second and third pastures begin November 1 of years two and three, respectively (Martin 1978).



Figure 3.--Fenceline contrast showing differences in forage conditions as a result of grazing practices. The pasture on the left is grazed yearlong; the other is part of the Santa Rita Grazing System.

Lehmann lovegrass (fig. 4) now grows on large acreages of southwestern rangelands. This cool-season, introduced grass is very productive. Once established it often becomes the dominant vegetation, and may spread rapidly.

Because cattle are reluctant to eat Lehmann lovegrass, special grazing management systems must be developed to utilize its production potential.

Lehmann lovegrass is most nutritious and acceptable to cattle during the vegetative part of the growing season. It initiates growth during winter and spring, and uses moisture not effectively used by warm-season grasses and forbs. It also competes effectively for moisture with mesquite, a dominant shrub on rangelands.

In situations where Lehmann lovegrass is well established and the dominant vegetation, the maximum productivity of cattle would be achieved through its use during periods of active growth.

Since its growth characteristics are different from those of warm-season native vegetation, it may be possible to achieve greater production through the complementary use of Lehmann lovegrass and native rangeland than from the use of either vegetation type by itself. In addition, the condition of native rangeland could be improved with such an integrated grazing management system that includes planned deferral on the native vegetation.



Figure 4.--Lehmann lovegrass (*Eragrostis lehmannia*) forms an almost pure stand on this site.

HOG CANYON MANAGEMENT AREA
(William L. Russell, Jr., Coronado National Forest)

The Hog Canyon Management Area, between Patagonia and Sonoita, Arizona, is a combination range, watershed, and wildlife area. Historically, the area has been important for livestock grazing as well as habitat for several wildlife species, particularly Montezuma (Mearns') quail (*Cyrtonyx montezumae mearnsi*). Recent range condition assessments indicated, however, that soil compaction, coupled with low vigor of native grasses, were responsible for lower forage productivity and reduced habitat quality for quail (fig. 5).



Figure 6.--The Hog Canyon bottom was ripped in an attempt to improve water infiltration and decrease overland flow and sheet erosion.



Figure 5.--Hog Canyon mesa top before ripping. Note the low vigor of grasses.

Soil compaction, particularly in the canyon bottoms, was resulting in lower water infiltration and increasing overland flow and sheet erosion during summer rainstorms (fig. 6). The native grasses (*Bouteloua gracilis*, *Heteropogon contortus*, *Leptochloa dubia*, and *Aristida* spp.) are warm-season growers and depend on critical summer moisture for growth.

Productivity and habitat quality were improved by (1) mechanical treatment, (2) reseeding, and (3) revising the grazing system on the allotment. The canyon bottom was ripped on 6-foot spacings, along contour lines, to an average depth of 15 inches. A mixture of Lehmann's lovegrass,



Figure 7.--Hog Canyon bottom one year after ripping.

weeping lovegrass (*Eragrostis curvula*), and clover (*Trifolium* spp.) was reseeded at a rate of 2 lbs/acre. The revised grazing system required fencing across Hog Canyon and 2 years of rest (spring 1979 through spring 1981) following project completion. Cattle will use the area every third year, beginning in 1981, thereby allowing two growing seasons of rest before use. Maximum allowable utilization will be 60% of annual production.

An evaluation in March 1981, showed substantial increases in forage production and vitality of native grasses. Production of native grasses (primarily *Bouteloua gracilis*) had increased to 450 lbs/acre in the canyon bottom compared to pretreatment production of 100 lbs/acre. Production inside a 40-year-old exclosure was 350 lbs/acre. *Bouteloua gracilis* responded well to the mechanical treatments, as was evident from the vigorous stands (fig. 7). Reseeded species were slow to establish, and took hold mostly on bare areas.

During the summer of 1980, an intense thunderstorm over the project area left little or no evidence of overland flow. In an area immediately down-stream in the canyon, however, the storm caused an overland flow several inches deep.

The mechanical treatments were largely responsible for: (1) reducing overland flow and sheet erosion, and (2) increasing water infiltration into the soil, where it was available for plant growth. The livestock grazing system is expected to maintain the vitality and productivity of the native grasses, while maintaining a quality nesting habitat for Montezuma quail.

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